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Notes of the Month

EXPERIMENTS at the National Physical Laboratory have resulted in the discovery of a method of measuring standards of length in terms of light. As briefly reported in *Discovery* last month, the basis of these measurements is the length of the wave of red cadmium light. Both the yard and the metre have been accurately measured in terms of this constant, such measurements having the advantage that they can be repeated exactly at any time and place where the necessary apparatus is available, with an accuracy of nearly one part in one hundred million. The materials at present employed for the standard units are liable to expand or contract slightly with time, and in any case are not nearly so exact. The full story of this remarkable research is told by Mr. H. Barrell on another page.

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The conclusion of Professor Huxley's article on "Religion as an Objective Problem" appears in this issue. We commented on his main contention in these columns last month, and subsequently Professor Huxley wrote to express regret that we should have thought fit to ascribe an unscientific attitude to him. "Surely," he writes, "the point is that in a brief article one cannot do more than give one's point of view; chapter and verse demand a longer treatment. This I have given some years ago in a large book, *Religion Without Revelation*, published by Ernest Benn Ltd. This point could easily have been brought out, and would have been insisted on by me if I had seen your comments beforehand." We have no quarrel with Professor Huxley but only with unwarranted dogmatism. We felt obliged to correct the impression, implied in his article, that belief in God is incompatible with a scientific approach to the question. It seems to us of the utmost importance that the layman should realize that, while any scientist is perfectly entitled to hold this opinion, he is not justified in stating it in such a way as to suggest that the question is settled once and for all. Actually, we doubt whether most scientists share Professor Huxley's views.

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Little of the earth's surface now remains which can be regarded as completely unknown. Since the war, previously inaccessible parts of New Guinea and desert Arabia have been crossed in the traditional manner; and the car and aeroplane have reduced the dangers of exploration, even in the Sahara and the central Asiatic desert, to a minimum which can be attained by efficient organization. It is unlikely, however, that any future improvements in transport will render polar exploration hackneyed, or its results so commonplace as to have little value for the advancement of scientific knowledge. The British Graham Land expedition, which leaves England this month with Mr. John Rymill as leader, will at least have before it the lure of the unknown. According to present plans, described in *The Times* by Admiral Sir W. Goodenough, two out of the three sledging seasons will be devoted to the exploration of territory at the back of the Weddell Sea and the area extending to the end of Falkland Islands Dependency, about which nothing is known at present. The expedition is well equipped for scientific research and it will be in the Antarctic until early in 1937.

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Professor Joseph Barcroft's address on "Experiments on Man," delivered at the annual meeting of the Research Defence Society, was a frank rejoinder to critics of the application of the results of experiments

on animals to man. It should reassure those—and they are numerous—who hesitate to accept the justification of such experiments on the ground of their service to humanity. It was admitted that in certain cases, reservations must be made; but as a rule, Professor Barcroft said, the results could be transferred to man and, generally, purely objective experiment did not require the use of man. In holding this position, he relied on no theoretical argument, but had himself submitted the matter to the test of practical experience, by exposing himself to the effect of prussic acid vapour in a lethal chamber in company with a dog. He was thus able to make a direct comparison of the effects. At the end of two minutes the dog was moribund, while he himself remained in possession of his faculties. The nature of the experiment renders it of peculiar value, in view of the increasing dangers from exposure to poisonous and unknown gases in modern industry.

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Sir Frederic Kenyon's letter to *The Times*, calling attention to the exhibition of English museum publications at the Metropolitan Museum of Art in New York, concluded with a pregnant suggestion which we hope will not be overlooked. He pointed out that an exhibition of this kind, if held in this country, would bring to our notice a good deal of which we are barely, if at all, aware. The excellent series of lectures now provided in the more important museums have done much to make our treasures better known to the public; but it is to be feared that too often both the casual and the regular visitor is apt to overlook the publications' stand, and thus remains unaware of the interest and range of the official publications in their various forms. Yet the large numbers who visited the British Museum everyday to view the Codex Siniaticus showed the interest which can be aroused if only suitable measures are taken. While the visitor to London may be able to go from one museum to another to find what interests him, the busy man's time would be economized by a joint exhibition such as Sir Frederic suggests.

The preliminary programme of the first International Congress of Anthropological and Ethnological Sciences holds out every promise of an interesting and important meeting. The Congress will meet from July 30 to August 4, at University College, London. The delegates will be received by the Duke of York at an inaugural meeting on the afternoon of July 30 when the Earl of Onslow, President of the Congress, will deliver an address; and in the evening a Government reception will be held at Lancaster House. The business of the Congress will be transacted in general and sectional meetings, in which communications covering all departments of anthropological science will be presented. Addresses on the present trend of research in anthropology will be delivered by Professor J. B. S. Haldane, Professor T. C. Hodson and Dr. R. R. Marett, while Sir Aurel Stein will deliver the Huxley Memorial Lecture of the Royal Anthropological Institute. Tickets may be obtained from the secretary, 52, Upper Bedford Place, London, W.C.2.

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Much interest has been aroused by the announcement that, in response to an invitation from the Royal Society, the International Union of Pure and Applied Physics will meet in London in October. The meeting will take the form of a joint conference of the International Union and of the Physical Society, held under the presidencies of Professor Millikan and Lord Rayleigh. The business will include a discussion on nuclear physics—the first of its kind to be held in London—and a discussion on certain aspects of the theory of the solid state of matter. There will also be presented a report from the Symbols, Units and Nomenclature Commission of the International Union, which should be of much importance in view of the rapid advance of the science in recent years.

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Tell Duweir, the Bibilical Lachish, where the Wellcome Research Expedition has been digging during the past season, has again proved a profitable site for exploration. Our readers may remember that an account of the earlier work appeared in *Discovery* last summer. In clearing the ditch of the Hyksos fortification uncovered last year, Mr. Starkey has now found a small temple which would seem to have been associated with an Egyptian form of worship. Apparently it was destroyed about the time of Ramses II in the thirteenth century B.C. Being situated sixty feet below the city wall, mud debris washed down by winter rains and earth thrown out by later builders in the city combined to preserve the ruins. One of the most interesting finds consists of pottery fragments on which is an inscription in the same script as that on a fragment of pottery found recently at Beth Shemesh, twenty miles away. We shall publish an article on these latest discoveries shortly.

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In these notes last month on the British Association programme, we referred to Sir William Bragg as the author of the evening discourse on the "Exploration of the Mineral World by X-rays." This will, however, be delivered by his son, Professor W. L. Bragg.

Measuring Length by Light Waves.

By H. Barrell, B.Sc., A.R.C.Sc., D.I.C.

Metrology Department, National Physical Laboratory.

Important experiments at Teddington have resulted in the discovery of a method of measuring the standard units of length by light waves. The present metal bars used for the purpose are liable to variation, while the new method will also have the advantage of being applicable at any time and place.

DURING the past ten years an investigation has been in progress at the National Physical Laboratory having for its object the formulation of satisfactory conditions to establish the length of a wave of light, as the ultimate basis of definition of the fundamental units of length. One most important part of this work has recently been completed. This consists of determinations, in terms of wave-lengths of light, of the present fundamental standards of length, namely, the Imperial Standard Yard and the International Prototype Metre.

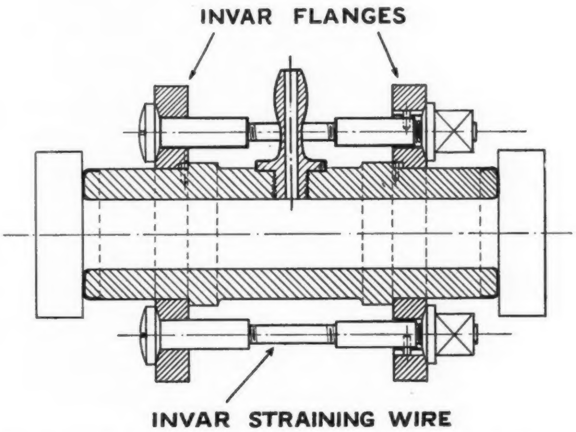


Diagram of the interferometer used at the National Physical Laboratory for the light wave experiments.

It is well known that light is propagated through space by means of minute electro-magnetic waves similar in character to those employed in wireless communications. The distance between the crests of successive waves is known as the wave-length, and light waves of a particular length are appreciated by the eye as having a particular colour. Certain rays, appearing in the spectra of gases and metallic vapours, are known to consist of waves which are remarkably uniform in length, and are therefore described as monochromatic, the red ray issuing from a cadmium lamp being especially good in this respect.

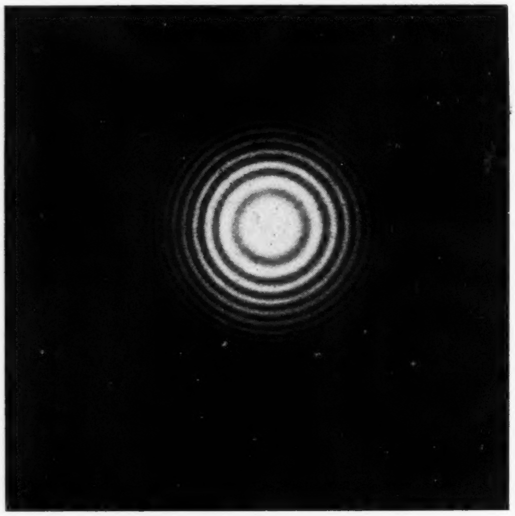
In future it may be possible to supersede the present definitions of the units of length, which are based on the distances between lines engraved on certain standard bars, by a definition in terms of the natural standard afforded by the wave-length of a monochromatic ray of light. Among the more obvious advantages which may be obtained by making this change are the avoidance of the risks of variation and damage associated with the present material standards. As showing the risk of variation, there is some reason for believing that the present Imperial Standard Yard has possibly changed its length by as much as two ten-thousandths of an inch since it was originally legalized in 1856.

The idea of establishing the fundamental units of length on a basis defined by some natural standard has long attracted physicists. The metre was originally intended to represent one ten-millionth of the earth's polar quadrant; and the Weights and Measures Act of 1824 prescribed that the yard, if ever lost or destroyed, should be replaced by reference to the length of a pendulum beating seconds in vacuum at sea level in London. The Standard Yard was in fact destroyed by a fire at the House of Commons in 1834, and great difficulty was experienced in its re-establishment, which it was found could not, with the certainty desired, be performed by the method laid down in the Act of 1824.

The first suggestion to use a wave-length of light as a standard of length seems to have been made by Babinet in 1829, but it was not till 1893 that Michelson and Benoît, working in Paris, made the first direct measurement of the metre in terms of waves of the red ray of cadmium. The comparison was made possible by a slightly modified form of the famous interferometer which Michelson had devised originally for the attempt to measure the relative velocity of the earth through the ether. Determinations of the metre in terms of the same wave-length have now been repeated by different observers, using different methods and apparatus, in France, Japan, England and Germany, all the results being in good agreement and within the possible limits of accuracy of definition of the present material standard.

The yard also has now been directly measured in terms of the same wave-length.

All the methods so far employed in the application of light waves to the measurement of length make use of some form of interferometer. The interferometer is an optical instrument which utilizes the property of interference of light waves. In the simplest type of interferometer a beam of monochromatic light waves is generally divided into two parts, and the two parts are caused to traverse paths differing in length. Then, after suitable re-combination of the two parts in the eye, either unaided, or better, in conjunction with a telescope, it will usually appear that the field of view is divided into some regular pattern of bright and dark bands or fringes. This effect arises from the fact that the trains of waves in the original beam, having been divided and having traversed different distances, arrive at the eye in different conditions. In the dark portions of the field the crests of the waves from one path mutually cancel or interfere with the troughs of the waves from the other path, whereas in the bright portions the crests and troughs of the waves from both paths mutually assist in producing additional intensity of illumination.



Interference phenomena produced by a 1/12-metre étalon, appearing as concentric bright and dark rings.

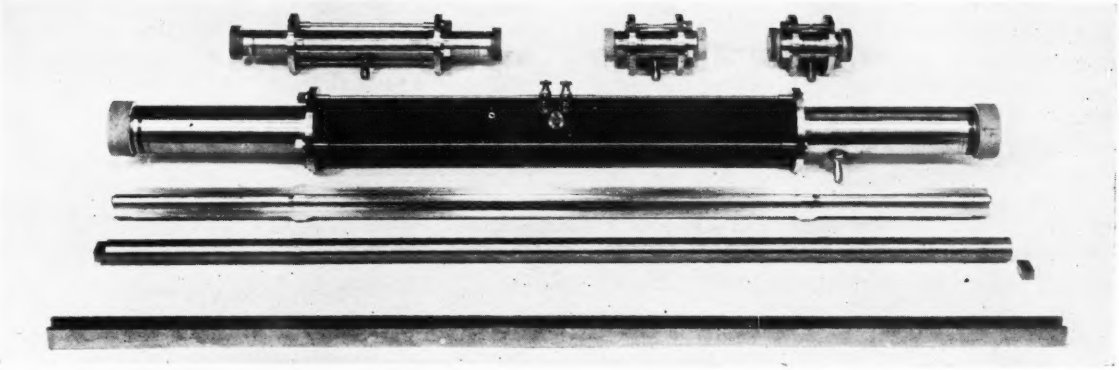
A diagram of the interferometer used at the National Physical Laboratory is shown on page 183. It is of the type known as the Fabry-Perot étalon, and in this particular form it consists of a metal tube having extremely flat and parallel end surfaces, to which are contacted polished flat plates of glass or natural quartz. The contact between the tube and plates is simply made by bringing the surfaces together in a clean and dust-free condition, whereby, owing to the close degree of approach rendered possible by the specially flat surfaces, they adhere to one another by molecular attraction. Each plate has a very thin silver film deposited over that portion of its surface which covers the bore of the tube, the film being capable of transmitting and reflecting certain proportions of the light which falls upon it.

When a beam of monochromatic light, such as can be obtained by interposing a red filter in front of a cadmium lamp, is directed along the axis of the tube, some of the light is transmitted directly through the two lightly silvered glass plates, while some of it is once internally reflected at each plate and eventually emerges in the same direction as the light which passes directly through. These two portions of the original beam, one of which has traversed an additional distance equivalent to twice the separation of the plates, are received in the object glass of a telescope and, to an eye placed at the eyepiece, the field of view is divided up into a system of concentric bright and dark rings, such as is shown in the photograph on this page.

If it were possible to increase slowly and continuously the distance between the plates of the interferometer, then it would be observed that the interference rings would move outwards from the centre of the system and new rings would form there. Actually the appearance of each new ring would signify that the double distance between the plates had been increased by an amount equivalent to a wave-length of the red light, which corresponds to about one forty-thousandth part of an inch. By measuring the diameters of the bright rings with the aid of a micrometer eyepiece fitted to the telescope, it would be possible to observe an increase in the distance between the plates of less than one two-hundredth part of a wave, or about one ten-millionth of an inch.

In practice the distance between the plates is fixed by the length of the tube, and the observations in the telescope are limited to measuring the diameters of two or more of the bright rings in at least three monochromatic rays of different colours, including the red ray of cadmium. It is then possible to derive from these observations the total number of waves of the red ray contained in the double distance between the plates.

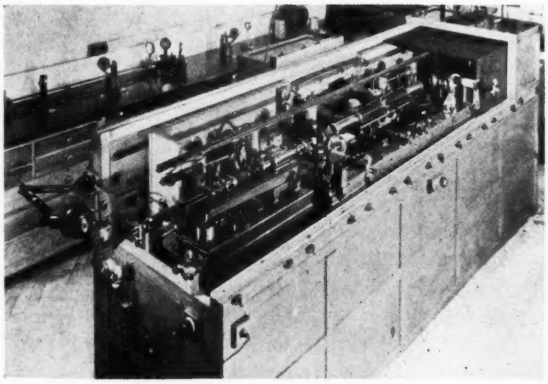
The tubular portion of the interferometer or étalon is made of invar—an alloy of nickel and steel which is little influenced in length by temperature changes. Its



Interferometers and other equipment used in comparing a wave length of light with an existing standard length.

end surfaces are plated with chromium in order to provide sufficiently hard surfaces for the finishing processes of grinding and polishing, and it is fitted with two flanges joined by straining wires which enable the length and parallelism of the étalon to be accurately controlled. Furthermore, since the joints between the plates and the tube are air-tight, the étalon can be evacuated through the nipple shown in the diagram and the distance between the plates can be measured, if desired, in terms of waves *in vacuo*. This feature is of great importance, for variations of atmospheric conditions cause variations in the length of a wave of light in air, whereas *in vacuo* the wave-length is a true natural constant. Alternatively, the étalon may be filled with air under known and controlled conditions, and the measurement can then be satisfactorily made in terms of waves in air.

It is not possible, unfortunately, to observe any direct interference phenomena with the étalon plates



General view of the apparatus in which the optical measurements are made at Teddington.

separated by a distance equal to either the yard or the metre, the most convenient separation for practical purposes being about 4 inches or 10 centimetres. But it is possible to compare by optical means the lengths of two étalons which bear a simple multiple relation to one another. For these reasons the basic measurement of length in terms of light waves is made in étalons nominally 1/12 metre or 1/9 metre long, either of which is then compared with an étalon 1/3 metre long, and this in turn is compared with an étalon 1 metre long. Actually, the longest étalon is rather longer than 1 metre, for a reason to be mentioned later, and the lengths of the other three étalons are adjusted to be simple fractions of the true length of the longest étalon.

In the procedure of optical comparison or multiplication ordinary white light is directed through the two étalons placed in line, and the light transmitted by the étalons is viewed through a telescope. Use is also made of the fact that the optical length of an étalon is slightly reduced when the étalon is inclined to the rays of light, there being a definite relation between the reduction in length and the amount of inclination. For this purpose, then, one of the étalons, that of 1/12 metre length for instance, is arranged with its axis exactly in line with the optical axis of the telescope, while the 1/3 metre étalon is mounted on a specially designed support which enables its axis to be inclined through small measured angles with respect to the axis of the telescope. Furthermore, the lengths of the two étalons are carefully adjusted by means of the straining wires, so that the 1/3 metre étalon is between one and two wave-lengths longer than four times the 1/12 metre étalon.

Under these circumstances a small group of straight and parallel interference fringes (known as Brewster's

fringes) is seen through the telescope, the group consisting of a central white fringe accompanied by a few coloured fringes on either side. The inclination of the 1/3 metre étalon is then adjusted until the central white fringe is situated at the centre of the field of view of the telescope, at which position it indicates that the optical lengths of the two étalons are in the exact ratio of 4:1, while from a knowledge of the angle through which the 1/3 metre étalon has been inclined with respect to the telescope axis the amount by which its true length exceeds four times that of the 1/12 metre étalon can be simply calculated. Similar operations are carried out between the 1/9 metre and 1/3 metre étalons, and between the 1/3 metre and 1 metre étalons; for both these comparisons the ratio concerned is 3:1. In such manner the departures of the series of étalons from their true nominal relationships can be precisely determined, and hence finally the number of wave-lengths in the longest étalon is ascertained.

The longest étalon carries along the bore of its tube a length standard approximately equal to one or other of the fundamental units, and it is for this reason that the étalon is made somewhat longer than 1 metre. The length standard is of the type known as an end-gauge, its length being defined as the distance between its polished, flat and parallel end surfaces. It is constructed of steel and has a cross-section in the shape of an X. Thus, when it is mounted in the étalon, four channels remain available between the arms of the X and the wall of the tube for the transmission of light during the optical comparisons with a shorter étalon. The length of the gauge may be determined if the small gaps existing between the ends of the gauge and the lightly silvered plates on the terminal surfaces of the étalon are measured. The direct measurement of each of these gaps in terms of light waves is made by a method similar to that applied to the shortest étalons, but here the interference takes place between light reflected from the plate and that reflected at the end surface of the gauge. Subtracting the value for the sum of the gaps from the value for the length of the longest étalon the length of the end-gauge is derived.

The Final Link.

Having thus standardized an end-gauge approximately equal in length to the yard or the metre, it only remains to compare the length of the end-gauge with the corresponding fundamental unit, which in both cases is in the form of a line-standard, i.e., one in which the standard length is defined as the distance between lines engraved on a metal bar. The comparison is made by a well established metrological procedure which involves the use of a special composite gauge that can be used either as an end-gauge or as a line-standard. This special gauge therefore constitutes the final link between the optically measured end-gauge mentioned above and the present fundamental units.

In the apparatus in which the optical measurements are made, the part comprising the étalons and their supports is mounted upon a thermally insulated concrete pillar which is isolated from the rest of the building. When in use the apparatus is enclosed in a double walled wooden enclosure in which the temperature is precisely controlled by means of a sensitive thermostatic regulator, the air within the enclosure being vigorously stirred by an electric fan to ensure uniformity of temperature. Temperatures are measured by special thermometers capable of reading to an accuracy of one-thousandth of a degree Centigrade. These great precautions in the control and measurement of temperature are necessary because it is valueless to measure length to a high order of accuracy unless the temperature of the measured object is known also to a correspondingly high precision.

New Definitions.

It has already been mentioned that the measurement of the étalons, and therefore of the end-gauge, can be made in air under controlled conditions and also *in vacuo*. Partly as a result of the investigation here described, it is considered that it will be more satisfactory to base the suggested new definition of the units of length on the length of a light wave *in vacuo*. The results of the recently completed determinations of the yard and the metre in terms of waves of the cadmium red ray *in vacuo* are 1 Yard=1,419,818.31 wave-lengths and 1 Metre=1,552,734.52 wave-lengths. The accuracy obtained in the optical measurements of length is between one and two parts in a hundred millions, which corresponds to an uncertainty in the yard length of less than a millionth part of an inch. This precision in the measurement of a physical quantity, although very high and at least five times better than that hitherto obtained in length measurements, is only of the same order as is already attainable in the comparison of the fundamental standards of mass on a first-class precision balance.

The proposed change in the basis of definition of length would not appreciably affect practical everyday measurements of length which would still be made, as formerly, by means of material standards. The important feature is that for the future the material standards could be verified at any time, and at any place where the necessary apparatus was installed, in terms of a natural, invariable and easily reproducible unit of length.

Science and Religion—IX.

Religion as an Objective Problem.

By Julian Huxley.

In the first part of this article last month Professor Huxley gave his view that, in the light of scientific enquiry, " God is simply fading away as the Devil has faded before him." Continuing the argument, he suggests that in future the religious impulse will find its main outlet in relation to the internal environment of the human species. Professor Huxley's views are discussed editorially on page 181.

THE disappearance of God means a recasting of religion, and a recasting of a fundamental sort. It means the shouldering by man of ultimate responsibilities which he had previously pushed off on to God.

What are these responsibilities which man must now assume? First, responsibility for carrying on in face of the world's mystery and his own ignorance. In previous ages that burden was shifted on to divine inscrutability: " God moves in a mysterious way " . . . Now we lay it to the account of our own ignorance, and face the possibility that ignorance on ultimates may through the limitations of our nature be permanent.

Control of Destiny.

Next, responsibility for the long-range control of destiny. That we can no longer shift on to God the Ruler. Much that theistic religion left to divine guidance remains out of our hands: but our knowledge gives us power of controlling our fate and that of the planet we inhabit within wide limits. In a phrase, we are the trustees of the evolutionary process and, like all trustees, responsible for our trust.

Thirdly and most urgently, responsibility for the immediate health and happiness of the species, for the enhancement of life on this earth, now and in the immediate future. Poverty, slavery, ill-health, social misery, democracy, kingship, this or that economic or political system—they do not inhere inevitably in a divinely appointed order of things: they are phenomena to be understood and controlled in accordance with our desire, just as much as the phenomena of chemistry or electricity.

Finally, there is the question of the immediate future of religion. Can science make any prophecy or offer any guidance in regard to this? I think that within limits, it can. In the first place, by analysing the reasons for the breakdown of the traditional supernatural religious systems of the west, it can point out that, unless the trend of history is reversed, the breakdown is an irremediable one. For it is due to the increase of our knowledge and control, the decrease of our ignorance and fear, in relation to man's external environment—floods, disease-germs, machinery, crop-production, physical and chemical invention—and unless science and technology disappear in a new Dark Age, this will persist.

The collapse of supernaturalist theology has been accompanied by the collapse, first of supernatural moral sanctions, and then of any absolute basis for morals. This too must be regarded as a process which, in the event of the continuance of civilization, is irreversible.

We can, however, go further. We have seen that the breakdown of traditional religion has been brought about by the growth of man's knowledge and control over his environment. But biologists distinguish between the external and the internal environment. Our blood provides our tissues with an internal environment regulated to a nicety both as regards its temperature and its chemical constitution, whereas the blood of a sea-urchin affords no such constancy. The organization of an ants' nest provides for the species an internal environment of a social nature. And in contrast with the rapid increase of man's knowledge of and control over his enternal environment, there has been little or no corresponding progress as regards the internal environment of his species. This is equally true in regard to the structure of society which provides the social environment for the individual and the race, and for the complex of feelings and ideas which provide the psychological environment in which the personal life of the individual is bathed.

Two Angles.

These two aspects of man's internal environment of course interact and at points indeed unite—witness the field of social psychology: but for the most part they can be best considered from two very different angles—on the one side from the angle of economics, politics, law and sociology, on the other from the angle of psychological science. Not only have we as yet no adequate scientific knowledge or control over these phenomena, but our absence of control is causing widespread bewilderment. The common man to-day

is distressed not only over his own sufferings, but at the spectacle of the helplessness of those in responsible positions in face of the maladjustments of the world's economic and political machinery.

The Modern Prometheus.

In this field the fear of the uncomprehended, banished elsewhere, has once more entered human life. The fear is all the more deadly because the forces feared are of man's own making. No longer can we blame the Gods. The modern Prometheus has chained himself to the rock, and himself fostered the vulture which now gnaws his vitals : his last satisfaction, of defying the Olympian tyrant, is gone.

The distress and the bewilderment are experienced as yet mainly in the more tangible realm of social and economic organization : the mental stresses and distortions arising from the social maladjustment remain for the time being in the background of public consciousness.

With the aid of our analysis of the nature and functions of religion, we can accordingly make certain definite assertions as to its future. The prophecy of science about the future of religion is that the religious impulse will become progressively more concerned with the organization of society—which, in the immediate future, will mean the organization of society on the basis of the nation or the regional group of nations.

The process, of course, has already begun. Many observers have commented on the religious elements in Russian Communism—the fanaticism, the insistence on orthodoxy, the violent " theological " disputes, the " worship " of Lenin, the spirit of self-dedication, the persecutions, the common enthusiasm, the puritan element, the mass-emotions, the censorship. A very similar set of events is to be seen in Nazi Germany. In that country, of especial interest to the scientist and the student of comparative religion are such phenomena as the falsification of history and anthropological theory in the interest of a theory of the State and of the Germanic race which serves as the necessary " theological " rationalization of the emotions underlying the Nazi movement, and the dragooning of the Protestant churches to fit them into the Nazi scheme of things. The new persecution of the Jews, which has its real basis in economic and social dislike, is justified on the basis of this new religiously-felt Germanism, just as the mediaeval persecutions of the Jews, which equally sprang from economic and social dislike, was justified on the basis of Christianity.

These are the first gropings of the human mind after a social embodiment of the religious impulse. They are as crude and in some respects as nasty as its first gropings, millennia previously, after a theistic embodiment of religion. The beast-headed gods and goddesses of those earlier times, the human sacrifice, the loss of self-criticism in the flood of emotional certitude, the sinister power of a privileged hierarchy, the justification of self, and the vilification of critics and the violence towards opponents—these and other primitive phenomena of early God-religion have their counterparts in to-day's dawn of social religion. And the general unrest and the widespread preoccupation with emotionally-based group movements such as Fascism and Communism, is in many ways comparable with the religious unrest that swept the Mediterranean world in the centuries just before and after the beginning of the Christian Era.

To achieve some real understanding and control of the forces and processes operating in human societies is the next great task for science ; and the applications of scientific discovery in this field will have as their goal what we may call the Socialized State. The religious impulse, itself one of the social forces to be more fully comprehended and controlled, will increasingly find its outlet in the promotion of the ideals of the Socialized State.

Exactly how all this will happen no one can say—whether the religious impulse will again crystallize into a definite religious system with its own organization, or will find its outlets within the bounds of other organizations, as it does for instance in the Communist party in Russia. We can, however, on the basis of the past history of religion, make a further prophecy. We can be reasonably sure that the inner momentum of logic and moral feelings, combined with the outer momentum derived from increasing comprehension and control, will lead to an improvement in the expression of this socialized religion comparable to the progress of theistic religion from its crude beginnings towards developed monotheism.

Intellectual Virtues.

Accordingly, we can prophecy that in the long run the nationalistic element in socialized religion will be subordinated or adjusted to the internationalist : that the persecution of minorities will give place to toleration ; that the subtler intellectual and moral virtues will find a place and will gradually oust the cruder from their present pre-eminence in the religiously-conceived social organism.

We can also assert with fair assurance that this process of improvement will be a slow one, and accompanied by much violence and suffering.

Finally we can make the prophecy that part of this

process will come about through interaction between two expressions of the religious spirit—one which strives to identify itself with the Socialized State, the other which reacts against the limitations thus imposed and strives to assert and uphold values that are felt to be more permanent and more universal. The cruder and more violent is the socialized religion, the more will it encourage such reactions. Already in Nazi Germany such a reaction has taken place among certain elements of the Protestant Churches, who feel that their principles embody something higher, more lasting, and more general than anything, however intense, which is at the basis of a nationalist and racialist conception of social aims.

The Near Future.

This is the one domain in which traditional religion, with its universalist monotheism, will in the near future have a real advantage over socialized religion, which for some time will inevitably be bound up with nationalist states.

It is probable, however, that a universalist Humanism (and probably Communism too) will soon become a strong rival of the old theistic systems in this field. It is also probable that with the growth of intolerant socialized feeling, both in Communistic and Fascist societies, the pioneers of such a Humanism will be those most exposed to religious persecution, but also those who will be going most for their form of socialized religion and for religious progress in general.

One final prophecy, and I have done. It seems evident that as the religious impulse comes to create these new outlets or expression, whether by way of the Socialized State or by way of Humanism, it will be increasingly confronted by psychological problems—as indeed will the Socialized State itself. Men will realize that economic and social planning will not solve their problems so long as ignorance and absence of control obtain in regard to their own minds. Psychological science will then come into its own, with social psychology as its dominant branch. And this will mean a new understanding of religious phenomena, and new possibilities of integrating them with the life of the community.

To sum up, I would say first that the so-called "conflict between science and religion" has been a conflict between one aspect of science and one aspect of religion. These aspects have both been concerned with man's relation to his *external* environment. The systems of religion which are in danger of collapse grew out of man's ignorance and helplessness in face of external nature; the aspect of science which is endangering those religious systems is that which has provided knowledge and control in this same domain.

Larval eels from the Sargasso Sea, part of the largest haul ever taken, which will be described in "Discovery" next month.

In the near future, the religious impulse will find its main outlet in relation to the internal environment of the human species—social, economic, and psychological—for it is the forces of this internal environment that are now causing distress and bewilderment and are being felt as Destiny to be propitiated or otherwise manipulated. Meanwhile science will find its main scope for new endeavour in this same field, since it is here that our ignorance and our lack of control are now most glaring.

There will again be a race between the effects of ignorance and those of knowledge; but with several new features. For one thing the growth of science in the new field will this time not lag by many centuries behind that of the new modes of religious expression; and for another, the facts concerning the religious impulse and its expression will themselves fall within the scope of the new scientific drive. The probable result will be that in the Socialized State the relation between religion and science will gradually cease to be one of conflict and will become one of co-operation. Science will be called on to advise what expressions of the religious impulse are intellectually permissible and socially desirable, if that impulse is to be properly integrated with other human activities and harnessed to take its share in pulling the chariot of man's destiny along the path of progress.

Plant Life in the Desert.

By Dr. Forrest Shreve.
Carnegie Institution Laboratory, Tucson, Arizona.

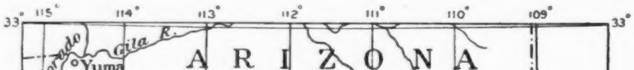
Expeditions conducted by the author have recently been made in the North American deserts to study the life of desert plants and other problems. Interesting results were obtained.

DESERT is commonly thought of as sandy or stony waste devoid of all life. As a matter of fact there are only a few very small spots in the whole world that would fit this definition. It is nearer the truth to think of desert as country with little rain, few streams, dry soil, high temperature, low humidity, and almost unbroken sunshine. It is a country in which the plants are very different from those of moist regions both in their structure and their physiological features. Some of its animals are of distinctive types, like the Gila monster and the horned lizard, and all of them have habits of life which have been greatly modified.

The United States is the only great power which has desert country within its home borders. Some of it is a pronounced type much like the vast unsettled regions in the colonies of Great Britain, France, Italy, and Portugal. Some of it is less arid and dotted with bushes and cacti. Along their margins the arid lands are bordered by semi-arid ones, in which agriculture is possible but difficult and precarious. Taken together the arid and semi-arid parts of the United States form twenty-four per cent of its area.

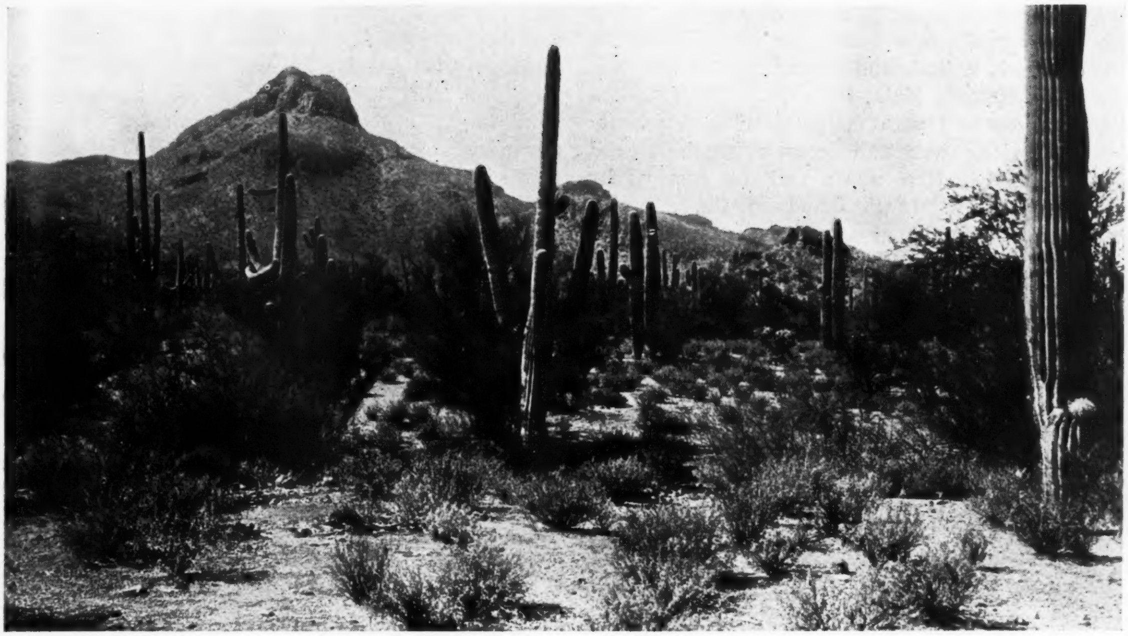
Investigation of life and conditions in the desert has been made by the Carnegie Institution of Washington for the past thirty years at the Desert Laboratory, which is situated at Tucson, Arizona, very close to the geographical centre of the North American desert. The aim of the work there is to study all of the features by which the plants of the desert have become suited to the conditions under which they manage to exist.

During 1933 members of the Laboratory staff travelled 2,600 miles over the deserts of Arizona and the State of Sonora in Mexico, studying the plant communities, following familiar trees and shrubs to the edges of their areas of distribution, and securing readings of rainfall and temperature from instruments placed in remote and uninhabited spots. These expeditions are made by automobile with an equipment which renders the party as independent as possible. Adequate supplies of food, water, and petrol are supplemented by provision for all ordinary motor troubles and any sort of reconstruction the roads may require. Often it becomes desirable to travel without the benefit of a road, and a driver familiar with the vegetation, and the sort of surface that it indicates, can pick his way so as to minimize the use of shovel and axe.



Map of the Sonoran Desert, showing the routes travelled by the recent expeditions. Over 2,600 miles were covered in Arizona and Mexico last year.

The life of a desert plant is an incessant struggle against adversity from the very start. Of the many seedlings which appear in the rainy seasons not more than one in a thousand survives to the next rainy period, and few indeed are the ones that live to reach full size. The scarcity of water, the desiccating effects of the brilliant sunshine, the dry air, and the almost constant wind, together with the ravages of hungry rabbits, mice, birds, and insects, all make life precarious even for the most hardy plants. A great deal has been discovered about the devices which help



Typical view in the Tuscon region of the desert, where the giant cactus (30 feet in height) and other plants grow together in great variety.

plants to meet arid conditions. Some plants grow and flourish during the rainy periods and dodge the whole problem of desert life by existing only as seeds during the dry months. Some of them build up a store of water in the rainy seasons which is great enough to supply their needs for a year or more. Others send their roots deep into the soil and secure every day a little water to balance what they have lost to the air. The plants in each of these groups have achieved certain advantages and at the same time have run into difficulties which limit their activity or restrict their distribution.

A complete list of the perennial plants to be found in the broad valleys and bare mountains of the Camino del Diablo (see map) is very small. Hardy creosote bushes are the commonest of these, growing up to within ten feet of each other in favourable spots or more often limited to a dozen plants to the acre. Whether there is the usual rainfall of four or five inches a year or no rain at all the creosote bush is at least able to survive. Like most other desert plants it grows and blooms when it can but spends most of its life marking time.

An expedition was made in the autumn of 1932 to the coast of the Gulf of California in Sonora, and thence toward the mountains by which the state is bordered along its eastern frontier. In the spring of 1933 the desert was traversed from the Bill Williams valley in western Arizona to the Mayo Valley in southern Sonora. These trips yielded a wealth of observations and material. Both of them were accompanied by Dr. Ira L. Wiggins, of Stanford University, who collected plants assiduously all day and shifted driers on them beside the camp fire nearly all night. His university is collaborating with the Carnegie Institution in the investigation of the south-western deserts, and is gradually building up the collections of the plants on which must depend the answers to many questions about the desert country.

Whence came the plants of these regions? What families and genera have contributed most to the flora? What has been the origin of the groups that are found only in this inhospitable area? To what extent have slow changes in a plant accompanied its migration into the desert? Are there groups of plants that have lived for countless centuries in the desert and have sent migrant representatives into moister regions? The answers to these questions are not yet ready but many hints are being found that give encouragement in their pursuit.

The expedition across Sonora from west to east was particularly fruitful in showing the importance of soil

conditions in controlling the distribution of the familiar plant communities over a route in which there was little change in latitude and consequently in temperature. An extensive plain, for example, was crossed which was covered with mesquite trees, commonly found only along rivers and known to require a good moisture supply. Here was a veritable orchard far from rivers or hills. It was found that the soil was a fine alluvial clay and that several streamways poured their water over the entire plain in the violent rains of the summer. As often happens in the desert there is no outlet from this plain and never will be until it is filled with soil to the level of some hindering pass in the seaward hills.

Moisture Supply.

A thorough investigation of just such a soil near the Desert Laboratory has shown that it has a nearly constant and wholly adequate supply of moisture at a depth of five to ten feet, no matter how hot and dry the summer may be or how parched the surface soil may become. In brief, the orchard of mesquites was drawing on a vast reservoir of water supplied to it by the rains of many square miles beyond its borders. And over these same square miles the plants had been robbed of some of their water by the inexorable work of gravity.

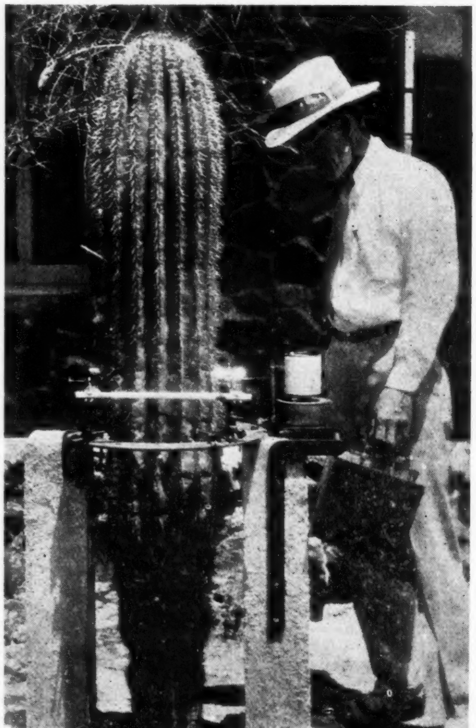
The southern lap of the expedition led from Tucson to the southern boundary of Sonora. To the right were the plains bordering the Gulf, far to the left were the foothills which culminate in the Sierra Madre range. The coast and the mountains slowly converge as one travels south, the rainfall becomes slightly greater, and the desert undergoes some profound changes, which it was the object of the expedition to examine.

The only path by which tropical plants might make their way at congenial altitudes into the North American desert is along the narrow strip of coast which broadens in the north to make the plains of Sonora and southern Arizona. In travelling we kept meeting plants of tropical relationship which have one by one pushed their way into the desert. Also we gradually left behind some of the plants which show the most striking development of structures designed to hoard or economize water.

The cactus family, for example, is much more varied and abundantly represented in southern Arizona than in southern Sonora. It seems very certain that the cacti colonized Arizona by moving north along the coastal path. It is as if an invading army was now massed along its advancing front and had left only a few detachments to occupy the conquered territory. As the cacti of the Sonoran Desert become better known and their areas of distribution more accurately drawn, much evidence is being found of the manner in which migration and the evolution of new species have gone hand in hand. It appears that struggling against adversity is a stimulus to progress and development in plants just as it is in man.

The traveller in the desert has a good deal of sympathy with the plants and animals about him for he too has the problem of water supply. Natural tanks in rock are very few and far apart. The wells in remote settlements are always open and their water subject to grave suspicion. Economy of water becomes a habit. A tin-cup of the precious fluid is agreed to be ample for a bath. The residue is carefully placed in the radiator of one of the cars. Fuel is to be found in certain places and the spot for an overnight camp is always selected with a view to its availability. The food supply depends on foresight, with occasional game or chance purchases of beans or eggs.

One evening on the way from the coast to the hills a



The author reading the record of a cactus taken with the dendograph, an instrument which registers plant variations.

Flower and buds of the giant cactus (previously shown on page 191), *which grow at the crown of the main trunk and branches.*

rather bare camping site was selected at sundown and Dr. Wiggins began to scout for wood. In the waning light he inadvertently stepped on the tail of a rattlesnake. Deprived of its customary means of warning intruders the snake became irritated and struck Dr. Wiggins in the leg. Fortunately his boots were heavy enough to break the fang. He killed the snake and brought it into camp, whereupon Mr. Turnage, assuming the rôle of deputy cook, decided to prepare it for dinner. After the rattler was skinned and cleaned slices were cooked with bacon and proved to be very palatable. Like many of the delicious fruits of the tropics there is nothing with which the flavour can be compared. Subsequently it was found that rattlesnake meat shredded with potatoes is a grateful substitute for codfish. The oranges of Sonora, when procurable, are cheap and excellent, serving to spare the water supply and to vary the unavoidable heaviness of camp diet.

When the expedition reached the Yaqui River region, we found camp life in the tropics wholly different from in the desert. The transition in every aspect of nature is borne home to the camper in many ways which corroborate the conclusions reached through study of the vegetation. New kinds of ants are encountered in increasing hordes, with voracious appetites for everything from bacon to gummed labels. Termites begin work in a few hours on a plant press thoughtlessly left on the ground. A whole new fauna of insects and small reptiles files out during the evening to see what the camp fire means. The open is preferable to the small villages, however, for their fauna is even larger.

The Yaqui is one of the largest rivers on the Pacific coast of Mexico, rivalling the old unharnessed Colorado in the strength of its floods and the size of its delta. The rich alluvial flats have in small part been brought under cultivation, and have become famous for the fine quality of the rice there grown. In order to reach southern Sonora it is necessary to cross the Yaqui. A single railway bridge is the only one that exists, and motorists are compelled to trust themselves to small ferry boats operated by poles and oars.

When we reached the river we found it running swiftly at a mid-flood stage and discovered that the stalwart ferryman was anxious to try out a new boat on which he could ferry two cars at once. We accepted the challenge, and in the quiet water of the lee shores safely crowded two cars on to the little boat, scarcely leaving standing room for the ferryman and his helpers. The handling of the boat while crossing the river was very skilfully done, and a good landing was made opposite a steep cut that had been dug in the twenty-foot bank on the swift side of the river.

The ferryboat, however, was not now securely tied up as it had been at the embarking place. The ferryman, with true Indian philosophy that every man should look out for himself, gave no warning that the removal of the weight of the first car might dump the second one into the river.

As the first one crept across the planks toward the steep dusty incline, Dr. Mallery, too alert to be so easily trapped, simultaneously moved the second car forward to a central position on the boat. The reserve of the ferryman and his helpers was now gone and they laughed approvingly. Throughout Mexico admonitions are few but resourcefulness is always applauded.

The region between the Yaqui and Mayo rivers is the frontier between desert and tropics. Like all transition regions it is of great biological interest, full of features which help to interpret the conditions that are limiting the various types of life found there. Beyond the Mayo only a preliminary survey has been made, but it is important to follow the transition region far enough to study the southernmost occurrences of the desert plants and the waning of the ecological features of desert vegetation. Much work remains to be done in investigating the tongues of desert which follow the larger rivers of Sonora far into the interior.

The Problem of Mimicry.

By F. A. Dixey, M.A., D.M., F.R.S.

The various theories that have been advanced to account for mimicry in insects are discussed by Dr. Dixey, who has studied the subject for fifty years. Naturalists disagree as to whether birds prey on butterflies, but it has an important bearing on the problem.

A FRESH chapter in the theory of evolution was opened by a paper published in 1862 by Mr. H. W. Bates, who had travelled and collected in the Amazon valley of South America. In the course of his travels he had noticed that many butterflies, conspicuous by their colouring and slow manner of flight, were imitated by other butterflies not at all closely related to them. These mimics inhabited the same districts as the species imitated, and were observed to be rare in comparison with their models. Similar instances of minute likeness between organisms of diverse affinities had been recognized before this, and had been regarded simply as curious coincidences, no suggestion having been offered as to the cause of these resemblances.

Deceptive Resemblance.

But Bates was not satisfied by simply recording the facts without seeking for an explanation. It seemed to him that these remarkable assimilations, so far from being merely due to coincidence, must have some bionomic significance. After a careful review of the relevant facts so far as they were known to him, he came to the conclusion that the reason for the departure of the rarer forms from the general aspect of their nearly related group, in the direction of the common, conspicuous and slow-flying butterflies, was an advantage to be secured by the former from their deceptive resemblance to the latter.

There were, he thought, grounds for supposing that the mimicked groups, known to him in the wide sense as Heliconids, enjoyed immunity, by reason of some unpalatable quality, from the attacks of insectivorous enemies, especially birds and lizards. This immunity or protection, if it existed, appeared to be shared by other groups, in Bates's experience chiefly by certain Pierids. The Pierids, a group consisting of the allies of our common whites, were in Bates's view a palatable and highly persecuted assemblage, and it seemed to him reasonable to suppose that many of their species should, so to speak, seek to shelter themselves by adopting the deterrent guise of the protected Heliconids.

It was realized by Bates that under some circumstances the presence of palatable mimics might be a danger to the distasteful models; for the reputation of the latter for inedibility would be lessened or destroyed by the existence alongside of them of butterflies indistinguishable from them in appearance, but possessing none of the distasteful qualities which caused their models to be avoided. This difficulty, in Bates's opinion, was met by the fact that the mimicking Pierids were so much rarer than the mimicked Heliconids that any such interference in the reputation of the latter must be negligible. But although a full consideration of the facts observed by Bates disclosed another difficulty to which he found no satisfactory solution, his explanation was accepted by Darwin and other naturalists as true as far as it went; and similar relations between model and mimic were soon afterwards described by Wallace for Malaya and Trimen for Africa. Bates had already pointed out that the resemblance long known to exist between such hymenoptera as wasps, whose stinging properties tend to protect them from attack, and certain moths which copy them closely in appearance and behaviour, was capable of a similar explanation; and it was widely allowed that Darwin's theory of natural selection provided an adequate means for the establishment of these mimetic relations.

A Difficulty.

Still, however, there remained the difficulty to which allusion has already been made. This was the fact that the distasteful or inedible models had a strong tendency to resemble each other. This was fully realized by Bates, who was quick to perceive that his view of the sheltering of the edible Pierids under the reputation of the inedible Heliconids could not be applied to the case of two inedible forms resembling each other. Some other explanation must be found for this phenomenon, which was of very wide occurrence among the protected groups of South American butterflies. The solution of the problem was due to Fritz Müller, whose contribution, published in 1879, threw new light on the whole question of mimicry. It had hitherto been generally assumed that the avoidance of prey rendered unsuitable by the possession of nauseous qualities, was a matter of *inherited knowledge*, or of instinct, on the part of the insectivorous enemies.

If this were so, Fritz Müller agreed, the resemblance between distasteful forms could not be explained

on the lines of Batesian mimicry. But if each enemy, say a young bird, had to *learn by experience* which kinds of prey were best left alone, it was evident that the number of victims necessary to complete the bird's education in this respect would be shared between all the possessors of a common appearance, whether they belonged to one, two or more distinct species. Hence follows the definite advantage to distasteful forms to be gained by, as it were, joining their forces, and so sharing, under a common aspect, the tax levied on them by birds "at school." If Müller's contention is well grounded, it follows that the resemblance between distinct species falls under two heads.

Protection.

In the first case an edible species gains protection by assuming the aspect of another species, or assemblage of species, which escapes attack in virtue of the possession of some quality which renders it distasteful to insectivorous enemies. This is the kind of mimicry detected by Bates, and that rightly goes by his name.

In the second case two or more, often many, inedible forms assume a similar aspect and thus enjoy a common advantage by virtue of uniting to share the toll levied on them by experimental tasting. This is the kind of assimilation which was explained by Fritz Müller, and often goes by the name of Müllerian mimicry. Strictly speaking, this latter is not true mimicry if that term is taken to mean the deceptive adoption by an edible species of a protective livery not its own. It is rather the extension of a sign of distastefulness over a number of organisms each of which is entitled to wear it in virtue of its own distasteful qualities. A good name for this sort of assimilation is that introduced by Professor Poulton, *viz.*, "synaposematism."

It is to be observed that the Müllerian principle of experimental tasting, if it is really effective, must operate among the models for Batesian mimicry no less than among the members of ordinary Müllerian associations. The question then arises: is it not to be expected that the models for Batesian mimicry, being *ex hypothesi* inedible, should fall into Müllerian assimilation? As a matter of fact, this is what very frequently happens; or it may be put like this—that a "homoeochromatic" assemblage, *i.e.*, one with a common facies, very often includes a Batesian or "pseudaposematic" element within it. But the Batesian constituent, if present, must, as we have seen, always be small in amount as compared with the Müllerian.

In a paper published in the year 1894, the present writer gave the results of an extensive study that he had conducted in the wing-markings of the Pierinæ, the sub-family which includes the common whites of our own country. Some members of this sub-family, which depart from the usual aspect of their nearest relatives and adopt that of Heliconidæ and other groups which appear to be more or less immune from attack by insectivorous foes, gave Bates, as has been seen, the material from which he constructed his theory of mimicry. But in considering the case of certain South American Pierines belonging to the genera *Pereute* and *Euterpe*, the writer found difficulties in attributing their very striking resemblance to Heliconine and Papilionine models to the simple operation of Batesian mimicry. Thus, there was some evidence that the Pierines in question were not rare in comparison with their supposed models, and there appeared also to be some reason for thinking that they might possess distasteful qualities. It had not been suggested so far that Pierines were constituent members of Müllerian groups, but from these considerations it seemed not unreasonable to suppose that their relation with the associated Heliconine and Papilionine models was Müllerian and not Batesian.

Furthermore, on a close inspection of the mimetic features in these groups, it seemed unlikely that certain features in which the Pierines resembled the supposed models were simply adopted from the latter, inasmuch as the features in question were common to many Pierines whose wide distribution in diverse parts of the world precluded the idea that these particular marks were due to imitation of certain South American butterflies; while the similar features in the latter were on the whole most distinct and most Pierine-like in those forms that were locally associated with the Pierine *Pereutes* and *Euterpes*.

Interchange of Features.

These facts suggested to the present writer that there might in these cases have been a certain amount of interchange between the members of these homoeochromatic associations; that although most of the features in the aspect of these Pierine genera might have been borrowed from the Papilionines and Heliconines, others might be supposed to have passed in the opposite direction, from the Pierines, that is, to the supposed models. For this interchange of features between the members of a Müllerian association, the writer, using "mimicry" in the wide sense, suggested the term "reciprocal mimicry." His friend, Professor Poulton, thinking that the term "mimicry" should be confined to the deceptive resemblance to a distasteful form employed by an edible one, *i.e.*, the

Batesian relation, in 1897 proposed as a substitute for "reciprocal mimicry" the convenient term "diaposematism," *dia*, as in "dialogue," conveying the sense of "giving and taking" or interchange. Further instances where this reciprocal borrowing appears to have taken place have since been suggested both by the present writer and by Professor Poulton. Their interpretation of the observed facts has been questioned mainly on mathematical grounds; but in the opinion of the late Professor H. H. Turner and of Professor R. A. Fisher such objections cannot reasonably be sustained.

Common Safety.

Since it is obvious that diaposematism can only take place in Müllerian associations, not in Batesian, it constitutes good evidence of the distastefulness of all forms between which it can be shown to occur. It may also be noted that although a "mimic" which is of relatively plentiful occurrence must be Müllerian, it does not follow that a mimic which is scarce is necessarily Batesian. Theoretically there can be no limit to the number of either individuals or species forming a Müllerian group. An assemblage of this kind is only strengthened, not weakened, by fresh accessions; all being more or less inedible, and so all contributing *pro tanto* to the common safety; and this remains true whether any given constituent is scarce or common.

Fritz Müller's well-known paper, an English translation of which was introduced by Mr. R. Meldola to the notice of the Entomological Society of London in 1879, was principally concerned with the minute resemblance borne to each other by two South American butterflies belonging to widely separated groups, each of which groups was believed on strong evidence to be protected by inedible qualities. But after propounding his explanation of this particular case on the lines above stated, Fritz Müller went on to a general discussion of the question, as follows :—

"If two (distasteful) species are concerned, of which one is very common and the other very rare, then the advantage falls almost entirely on the rarer species," *i.e.*, the latter has every inducement to mimic the former, the former practically none to mimic the latter. "On the other hand, if two or even several distasteful species are about equally common, resemblance brings them a nearly equal advantage, and (if) each step which the other takes in this direction is preserved by natural selection—they would always meet each other numerically so that finally one would not be able to say which of them has served as the model for the others," *i.e.*, the loss suffered by the diminishing numbers of unaltered A would be compensated by the advantage gained by the increasing number of those individuals of A which began to share in the protective aspect of B, and *vice versa*; hence A and B would "meet each other numerically."

"In this manner," he goes on to say, "are explained those cases where several allied distasteful species resemble one another—cases where such resemblances cannot be regarded as inherited, and yet where neither of the species appears to claim to have served as a model for the others. To this category *Ituna* and *Thyridia* may belong" (these being the butterflies, members of widely separated groups, which formed the primary object of his discussion) "although the first has probably made the greater step in passing from the former dissimilarity to the present resemblance of the two species," *i.e.*, if distasteful species of *allied* genera, *e.g.*, of *Colaenis*, *Eueides* and *Dione*, can in this way be brought to resemble each other, the same principle may serve to explain the assimilation between those of widely separated genera such as *Ituna* and *Thyridia*.

In these passages it appears that the possibility is implied of a mutual approach between distasteful species; the idea, however, is not developed by Fritz Müller, nor are details supplied by him of the supposed interchange. The theoretical possibility thus advanced had not occurred to the present writer when from a consideration of the actual features of certain synaposematic butterflies he was led independently to frame the hypothesis of "reciprocal mimicry" or diaposematism.

Model and Mimic.

In 1915 Professor Poulton drew attention to a preliminary account by Fritz Müller of his theory; which account was published in 1878, and, as Professor Poulton remarked, had probably escaped the attention of naturalists. In this note Fritz Müller first demonstrates the superior advantage enjoyed by the numerically smaller species in a synaposematic combination, and then goes on to say, "This consideration shows further, that in all probability in many cases (*e.g.*, *Thyridia* and *Ituna*) the question which of the two species is Model, and which is Mimic, is idle; each has reaped some advantage from being like the other; they may even have gone to meet each other." This, a still more distinct suggestion of the possibility of reciprocal interchange, was unknown to the present writer until it was brought into view by Professor Poulton.

It is obvious that the validity of the interpretation

thus given to the phenomenon of mimicry in butterflies, whether of the Batesian or of the Müllerian order, depends on the answer that may be forthcoming to the following questions: (1) Do birds and other insectivorous animals prey upon butterflies? and (2) If they do, do they exercise a preference for one kind over another? To both of these questions an affirmative answer can be given. It is true that good naturalists have declared that they have never seen a bird eat a butterfly; but negative evidence of this kind is of little weight in comparison with the positive testimony that, since attention has been drawn to the point, has now become available in considerable quantity from the observations of naturalists in the field, especially of Marshall, Swynnerton, Neave and Carpenter. Many of these observations, with much other interesting information on the subject, are recorded in the recent book on "Mimicry" by G. D. H. Carpenter and E. B. Ford (Methuen).

It must not be forgotten that the phenomena of mimicry are by no means confined to butterflies, or even to the class of insects. But if the theories which took their start from the facts disclosed by the study of butterfly life in the tropics are well grounded, there is no difficulty in applying them to cases of mimetic resemblance that are to be found among members of other classes and orders, as, for instance, between insects and spiders. And it may safely be affirmed that no explanation which ignores the principle of natural selection will be found to cover the facts.

New Forms of Fossil Apes.

An expedition of geological and palæontological exploration in Northern India, sent out by Yale University, has recently returned to the United States after a year's work in the Siwalik Hills and adjacent Himalayan area. The results are noteworthy, especially in connexion with our knowledge of fossil anthropoids and the distribution of man's early stone age industry. At present only a preliminary report is available; but as the results have received little attention in this country, a brief summary may be given, subject to any modification which may be necessary later, as a result of more detailed study of the material acquired.

The Siwalik Hills are well known to be rich in the remains of fossil apes such as Siwapithecus. Various forms of fossil apes, some very small, some of considerable size, are known to occur in deposits of the Tertiary geological epoch from the Oligocene phase of that epoch onward in Egypt, Central Europe and Northern India. These fossil forms have thrown much light on the order of development and affinities of monkeys, anthropoids and man. Dryopithecus, for example, a large-sized anthropoid of which no less than six species have been recognized, and Siwapithecus (both belonging to Miocene times and both more highly developed than any other fossil anthropoid), if not the actual ancestors of the orang, chimpanzee and gorilla, must be very close to the form from which these simians developed, as well as near to the human line of descent. Hence any further discovery of new forms of fossil apes is of considerable importance.

The Yale expedition, which was directed by Professor Hellmutt de Terra, Research Associate of the Peabody Museum of Natural History of Yale, has discovered fossil jaws of apes structurally resembling those of Siwapithecus and Dryopithecus, but which, it is claimed, are to be classified as belonging in one instance to a new species, and in two others to new genera representing a much closer affinity to the main stem of man's descent. Of these the one, for which the name of Sugrivapithecus is suggested, has a relatively well-developed chin, such as is not found in living anthropoids; the other, Ramapithecus, is represented by an upper jaw in which the teeth are set in a rounded V, approaching the human form, instead of the U-shape, characteristic of the anthropoids. The lower jaw of Sugrivapithecus also shows an approach to this form, and in both the size and arrangement of the dentition inclines to the human rather than the anthropoid.

It is unlikely that the further detailed examination to which these specimens are being submitted will do more than amplify and confirm these conclusions. While there is no suggestion that these forms are in any sense ancestral to man, their divergence from previously known fossil forms in the direction of the human is highly significant, and marks a distinct advance in understanding of the line of human descent.

Human artefacts were discovered in later deposits. These were primitively shaped implements of volcanic rock and hard limestone found with the remains of mammoths and hooved animals. Remains of the early Stone Age, known from Southern India, had not previously been found in Northern India. Many fossils of other animals, elephant, rhinoceros and hippopotamus, etc., as well as gigantic land tortoises, were found in the region. Detailed geological and biological investigations were also carried out, which suggested that the Himalayan uplift already known to have been late, had taken place, in part at least, at a much later date than has been thought hitherto.

Science Explores the Soil.

By G. V. Jacks, M.A., B.Sc.

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Numerous agencies are constantly at work affecting the soil, and in dealing with recent developments in soil science the author gives us a glimpse of the comparatively new science of "pedology."

THE study of the soil in relation to the growing of crops, by discovering means of increasing and maintaining soil productivity, has added enormously to the wealth of the world: so much so that the soil scientist is sometimes blamed for the present universal impoverishment of the farming community. The practical results are seen in crop yields unthought of a generation ago, and in formerly barren lands producing harvests as rich as any in the world.

During the last fifty years, however, there has developed along with applied soil science a pure science, to which the rather unsatisfactory name of "Pedology" has been given. Pedology is the study of the soil in relation to its natural environment, in which respect it is analogous to ecology. In ecology, the soil is regarded as one of the environmental factors affecting the nature and distribution of plant associations, whereas in pedology the vegetation is regarded as a factor influencing the development of soil types. It will be seen that the two sciences are closely inter-related; both are young and began independently of each other, but they are now gradually approaching a common standpoint.

Soil and Climate.

An outstanding feature of pedology has been the development of the concept of soil "types." Formerly soils were regarded merely as the products of weathering of different kinds of rock, and were classed as sands, clays, granitic or basaltic soils, etc. But whereas these soil classes (or "varieties" as they are now called) are distributed at random throughout the world, the distribution of soil types is quite regular and approximately coincides with that of climatic types. The soil variety can usually be assessed by feeling the texture of the surface with the fingers, supplemented by a few laboratory estimations and a knowledge of the surface geology. The soil type, however, has to be judged by a careful study of the whole "profile," *i.e.*, the vertical section from the surface down to the unaltered rock beneath.

The innumerable agencies, biological, physical and chemical, which have acted on the original rock from the time it began to weather leave their marks on the profile which thus presents a complete, though never fully understood, picture of the soil's history. For instance, the origin of the soil—whether sedentary—transported, alluvial, glacial, etc.—is indicated by the geological stratification of the profile, and by the nature and shape of any pebbles and stones that occur. Important chemical properties are indicated by the form of the soil aggregates, *e.g.*, alkali soils break up into large columns, neutral soils into granules, while acid soils often exhibit a laminated structure. These phenomena are closely connected with the properties of colloidal clay. Clay behaves like an insoluble weak acid, in that it can react with, and adsorb the actions of electrolytes in the soil, forming clay "salts," each

Fig. 1.—"Podsol" in North-West Manitoba, under grassland recently reclaimed from forest. (Photo, Prof. J. H. Ellis, Winnipeg.)

Fig. 2.—"Chernozem" type soil under grass, near Winnipeg.

of which has distinctive characteristics. In the presence of sodium salts, a sodium clay is formed which, being the salt of a weak acid, has an alkaline reaction. Similarly, a neutral calcium clay is formed in a soil rich in lime, and a hydrogen clay (the clay "acid") in a soil poor in bases. The clay acid and its salts have characteristic structures, shown by the shape of the aggregates into which the soil breaks up.

But the most typical features of a mature soil profile are produced by the continued action of climate working both directly on the weathering of the rock and, perhaps more important still, indirectly through the vegetation.

Climate affects profile development chiefly through its influence on the movement of water in the soil. In a humid climate, where the rainfall exceeds the amount of water that evaporates from the soil, the movement of water is downwards, and the products of weathering are leached out from the surface layers, while in an arid climate where evaporation exceeds precipitation, water moves upwards and soluble material in the soil accumulates at or near the surface. In the course of time, the predominant upward or downward movement of water will produce a definite stratification of the profile, distinct from the geological strata, and typical of the climate under which the soil has formed. These pedological strata, which are termed "horizons," are the first things to be noted in studying a soil profile.

Superimposed on the profile features produced by geological, chemical and climatic influences are others produced by biotic influences, and particularly by the vegetation. With the aid of sunlight, plants synthesize organic matter, which ultimately returns to the soil on the death or defoliation of the plants. These plant residues supply the food of a multitudinous micro-organic population, by which the residues are decomposed and become incorporated into the soil as the dark coloured, highly complex colloidal substance known as "humus." The properties of humus vary considerably according to the type of vegetation from which it has been formed; steppe humus, moorland humus, deciduous or coniferous forest humus, each has particular properties, and affects soil development differently and to such an extent that certain profile types are almost invariably associated with corresponding vegetation types. The profile features most closely connected with the nature of the humus are those of colour, and the shades and changes of colour throughout a profile form one of the most certain indications of the type to which the soil belongs.

Many other factors, such as relief, drainage, the activities of bacteria, and of insects and animals living in and on the soil effect the structure and appearance of the profile. Any of these soil forming factors may mask, modify or intensify the effect of others, with the result that the complete picture presented by the soil profile is often exceedingly complex. Nevertheless, it is possible to classify the soils of the world into a comparatively small number of sharply defined types, which merge into one another through a much larger number of ill-defined transitional types. The well defined "normal" type is produced wherever the influence of vegetation and climate has for a long period been allowed full play, undisturbed by factors such as erosion, bad drainage, hilly relief, fire, human interference, or some special property of the parent rock. Under such conditions, the distribution of soil types is directly related to climate, since the great vegetation types such as moor, forest and steppe are also climatically distributed.

A Vast Plain.

Probably the best example in the world of the climatic distribution of soil types is to be found in Russia, where a vast plain with a more or less uniform geology extends from the Arctic through the cool and warm temperate regions to the hot, arid lands in the South. The climatic soil types were first described in Russia, and many of them received Russian names which, since the same types have been found in other countries wherever similar or equivalent conditions occur, have now been universally adopted.

Before proceeding to a description of some of the chief soil types, it will be well to tabulate them with

reference to the corresponding climatic and vegetation conditions under which they normally develop.

SOIL TYPE.	CLIMATE.	VEGETATION.
Tundra.	Perpetually cold.	Treeless moor.
Podsol.	Cold humid.	Coniferous forest, heath.
Chernozem.	Continental with, say, 20 inches rainfall.	Grass steppe.
Solonchak. Solonetz.	Hot, arid.	Xerophytic shrubs and grasses.
Lateritic soils.	Moist tropical.	Almost any tropical plant association, including rain forest and savanna.

These five types of soil may now be discussed individually.

Soil Types.

(1) *Tundra Soils.* These represent the soil type associated with the coldest limits of plant growth. The soil profile is simple, as the "soil" consists of slowly decomposing peat formed from the moss and lichen vegetation. The peat overlies a permanently frozen mineral substrate which is devoid of life and to all intents and purposes behaves like a solid block of ice. Consequently, there is no vertical drainage, and the tundra is usually waterlogged. The tundra is the simplest of all soil types ; its characteristics depend entirely on the nature of the vegetation, which is strictly limited and controlled by the climate. The effect of all other soil forming agencies is negligible.

Passing to more temperate regions, the limit of tree growth is reached, and the tundra soil is replaced by the podsol.

(2) *Podsols.* The podsol is the most prevalent soil type of the vast coniferous forest regions which extend in a wide belt across the northern parts of Asia, Europe and North America. It is also often found under heather moors, and may be seen on most of the English heaths and in the pine and spruce forests of Scotland.

A good example of a podsol profile, showing its typical features, is illustrated in Fig. 1. On the surface is a layer of peaty material—"raw humus"—derived from decaying plant residues, *e.g.*, forest litter. This is known as the A_0 horizon. Below, and sharply divided from it, comes a horizon (A_1-$_2$) of mineral soil, of loose texture and grey to white in colour, and then the B horizon, more compact than the A, and red, brown or black in colour. The B horizon shades off gradually into a lighter coloured C horizon—the parent rock, in this case a calcareous glacial drift, seen in the right-hand bottom corner of the photograph.

The colours of the different horizons of a podsol profile are one of its most important features. The colour of the A_{1-2} horizon is often grey, from the presence of highly dispersed or soluble humic matter originating from A_0, but the actual mineral particles have been bleached white by the almost complete removal of iron compounds, which are re-deposited as oxides or hydrates in the B horizon, giving it the dark red or brown colour which is its distinguishing feature. The leaching and subsequent deposition of iron (and aluminium) oxides is a characteristic of all podsols, and is, in fact, generally referred to as "podsolization." Podsolization only occurs under a particular combination of climatic, ecological and geological conditions. In the first place, to effect the transport of the iron compounds there must be a downward movement of water through the soil, *i.e.*, podsols develop in a definitely humid climate where precipitation exceeds evaporation from the soil.

Chemical and mechanical leaching of the surface soil should, however, take place in all humid climates, but it is only in podsol regions that the main constituent affected is iron. It is here that the ecological factor comes in. The iron compounds move through the soil in adsorptive or chemical combination with humic matter, and the necessary combination can only be made with certain kinds of humus, and particularly with acid humus, which has the property of decomposing complex rock silicates and combining with the iron, and possibly the aluminium, in them.

Plant Residues.

The acidity of a layer of raw humus depends primarily on the amount and nature of the bases in the plant residues from which it is derived. This in turn depends on the plant species and on the chemical composition of the soil. The basic material—*i.e.*, the ash—of any given plant varies within quite narrow limits, regardless of the nature of the soil on which it grows, but generally plants poor in bases, and therefore producing an acid humus, only occur naturally on acid soils.

The necessary conditions for podsol formation are therefore (1) a humid climate, (2) an acid soil, and (3) an acid-humus-producing flora. The intensity of the conditions may vary considerably, a high intensity of one compensating for a low intensity of another. Thus, podsols occur on the very acid granitic soils of Dartmoor, although the climate is too mild to be regarded as "podsolizing," and granitic soils in Central Europe are also often podsolized although covered with beech, which produces a less acid humus than conifers. In such areas, however, the beech forest is unstable, and if left to itself, would give way to conifers.

It should be noted that the parent material of the soil illustrated in Fig. 1 is calcareous and therefore *alkaline.* In all probability the soil was formerly a "chernozem," with a prairie grass vegetation. In the humid climate, however, the calcium carbonate was leached from the surface, and has been redeposited in a "carbonate accumulation horizon," which can be seen at the bottom of the photograph. The leaching of the calcium carbonate (and other bases) gradually increased the acidity of the soil, until untimately an acid-loving forest vegetation was able to oust the grass. As the forest developed, a layer of raw humus formed on the surface, and podsolization set in.

This is a good example of the evolution of one soil type to another. Although the climate is a podsol climate, a chernozem originally developed owing to the influence of the calcareous soil on the vegetation. But the continuing action of climate has acted on the locality in such a way as finally to produce the true climatic climax types of both vegetation *and* soil.

(3) *Chernozems* (Black Soils). These are always associated with a grass steppe vegetation, never with forest. As mentioned above, when forest invades the steppe, the soil becomes "degraded" to a kind of podsol. Fig. 2 illustrates a chernozem soil, situated about 150 miles south-east of the podsol in Fig. 1, and formed from a chemically similar parent material. This particular chernozem has been considerably modified by local influences, but the essential features of the type are apparent in the photograph. These features are the black, granular surface horizon, which may be up to six feet in depth, and the underlying horizon impregnated with calcium carbonate which

Fig. 4.—Sodium "Solonetz" on irrigated land in South Russia.

may appear on the profile either as a general efflorescence or as separate concretions. The climate in which the chernozem is stable is one in which precipitation and evaporation are about equal. The downward movement of water during the wet season is counterbalanced by an upward movement in the dry season, and except for the accumulation (from above and below) of calcium carbonate, there is no marked movement of any soil component. The whole black horizon is remarkably uniform in composition, and has a neutral reaction. Unlike the acid humus of a podsol, the neutral humus of a chernozem has no leaching properties; instead, it flocculates the clay colloids into small, nutty granules, which impart an almost ideal tilth to the soil. Chernozems are very fertile and include most of the great wheat lands of the world.

(4) *Solonchak and Solonetz.* In hot, dry regions, the supply of ground water exerts a greater influence on soil development than the scanty rainfall. Where drainage is good, and the water table deep and inaccessible, the soil type is mainly determined by the nature of the usually only partially weathered parent material, but wherever a permanent water table exists, ground water tends to be drawn towards the surface,

Fig. 3.—"Solonchak" in Manitoba, the dark colour of the surface horizon being artificially produced by cultivation.

and to precipitate in the upper horizons any soluble salts which it contains. Owing to their high solubility, sodium salts when present in the ground water are particularly liable to move upwards and usually predominate in the saline soils, or "solonchaks" of arid regions.

Fig. 3 illustrates a typical solonchak, with white salt concretions scattered throughout the profile. The salts, being strong electrolytes, flocculate the clay colloids and give a structureless soil which, owing to the scarcity of natural vegetation, is very poor in humus. The structureless appearance of the soil should be compared with the marked structure of the "solonetz," shown in Fig. 4. The solonetz develops when the salts of a solonchak are washed out, causing deflocculation of the sodium clay which contracts, on drying, into hard, column-shape clods. These can be clearly seen in Fig. 4, and below them a white efflorescence of salts which have been washed down from the surface layers.

When moistened, the deflocculated, salt-free sodium clay absorbs large quantities of water and acquires an almost jelly-like consistency, which makes it impossible to work. When dry, it breaks into hard columns which are equally intractable, and its alkaline reaction is inimical to all but a very few plant species. The sodium solonetz is one of the most infertile soil types, and its formation by the leaching action of irrigation constitutes the well-known "alkali problem" of irrigated lands.

(5) *Lateritic soils.* In the hot, moist tropics the most characteristic soil forming process is "lateritization." Under the intense weathering conditions, the mineral silicates are more or less completely broken down to silica and oxides of iron and aluminium, and the *silica* is leached out, leaving a residual soil rich in aluminium and iron, which gives a characteristic red colour to tropical soils. Lateritization (silica leaching) may be considered as the reverse of podsolization (iron and aluminium leaching). Podsolization occurs under conditions favouring an accumulation of raw humus, whereas lateritization occurs in regions where, owing to the very rapid and complete oxidation of plant residues, humus can scarcely exist.

The detailed structure of different examples of the same soil type varies widely, in the same way as the details of forests or meadows vary, but the type characteristics, as described above, are always discernible either by visual inspection of the profile or by analysis. The soil profile reflects the history and biotic evolution of its environment, and considering the infinitely varying conditions under which the soils have developed, it is remarkable that we are able to classify them in quite a small number of major types.

2,500 Pictures a Second.

An ultra high-speed motion picture camera, which takes up to 2,500 photographs in a second and records time in one-thousands of a second, was demonstrated at Bush House, London, on June 12th. This has been made possible by an electrical timing apparatus produced by the Western Electric Company, in conjunction with a new high-speed motion picture camera designed by the Kodak Company. It uses 16 mm. film, and has two lenses so arranged that one photographs action pictures and the other photographs the moving dial of an electric clock in the timing apparatus. Action and time are thus simultaneously recorded, the clock dials being reproduced in the margin of each picture.

Some of the uses to which the high-speed camera will be put are that of checking the precision of fast moving machinery and locating errors, as well as solving various industrial and research problems. A modification of this apparatus has been specially designed for recording sporting events. The clock is set in operation electrically by the starter's pistol, and the camera photographs all the competitors as they cross the finishing line, simultaneously recording the time taken by each. Exact results are thus obtained.

The new high-speed camera uses fifty feet of film per second at full speed, about twenty times faster than the usual "slow motion" films shown in cinemas. It records movements not detectable by the naked eye.

The Nature of the Universe.

By Herbert Dingle, D.Sc.
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Professor Dingle here summarizes our present knowledge of the universe, showing that the position is one of extreme uncertainty. This discussion will be of particular interest to those who read Dean Inge's views on the future of the universe, in the May issue of DISCOVERY.

FEW terms in scientific thought are so difficult to define as the universe. Vaguely speaking, it is the totality of physical existence. But is there such a totality, or is physical existence infinite? And since, in any case, we find no evidence of even an approximate exhaustion of the material to be observed, how can we talk at all about the universe and remain scientific? These questions, one would think, would demand an answer from all who set themselves to discuss this most fascinating of themes, yet with a splendid disregard of all that they imply, the physicists and astronomers of the present age bring the utmost resources of their intellects to bear on a problem of which they can neither state the terms nor test the solution.

It was not always so. For the greater part of our era the universe was not merely a fit object of astronomical thought; it was the only object of astronomical thought. The Sun, Moon and planets, each in its crystalline sphere, revolved in eternal harmony round the central Earth, and outside them the firmament, containing all the stars, separated the physical regions below from the heaven of heavens above. The problem of astronomy was the problem of the motions of the whole universe. The partial problems which engage us now did not exist. One star differed from another only in glory, which was a spiritual attribute; it differed not at all in motion, distance, age, evolution, or indeed in anything with which the astronomer could concern himself. Astronomy was synonymous with cosmology.

Unending Space.

The transition from Ptolemaic to Copernican ideas of course destroyed the simplicity of this situation. The firmament was abolished, and instead of a material sphere we were faced with unending space. The invention of the telescope brought further difficulty. The orbs of heaven were not restricted to those we could see; there were still fainter—and doubtless yet more distant—stars. Just as there were no limits to space, so there might be no limits to the number and distance of the bodies scattered in space. The idea of infinity grew up, and from the contemplation of the whole men turned to the examination of the part, because the whole was inapprehensible.

But human aspiration seems impelled to transcend the partial. Push the universe out at the door, and it flies in at the window. Observation could shut itself in the laboratory, but thought roamed through the newly-discovered infinity, and it was not long before a compromise was reached. A hundred years after Copernicus had unwittingly destroyed the conception of the universe by making it infinite, Newton showed that the infinite was not necessarily the totally incomprehensible. True, we could not see it all, but it was possible to conceive of it as possessing certain general qualities which pervaded it wholly, so that from a study of even the minutest part one could determine the characteristics of the whole.

Universal Principles.

The way to do this was to abstract, from as wide a range of observation as possible, all the general principles one could. Newton himself thus unearthed his laws of motion and gravitation and showed that they were implicit alike in the motions of Galileo's falling bodies and those of Kepler's planets. It was a fair presumption, then, that they were implicit in all motions throughout space; one could, in fact, call them "universal." In this ingenious way he cut the Gordian knot entangling the transcendental character of infinity with the insatiable impulse of the human mind to grasp the whole of creation.

It is worth while to pause to see what this compromise meant, for it lies at the very heart of scientific thought to-day. In the old days the universe was both observable and describable in its entirety, and the description was simply a description of observation. When, therefore, complete observation was shown to be impossible, complete description became impossible also. Newton, however, in Platonic fashion, virtually regarded the universe as the embodiment of an idea, and he showed how the idea could be described although the embodiment could not be observed. The old gibe, that mediæval philosophy consisted in sitting in an arm-chair and spinning the web of the universe out of the brain instead of going out and looking at it, is unjust so far as cosmology is concerned. It was the older astronomers who described what they saw, and Newtonian mechanists who described what

they deduced. Newton characterized the universe, not by the distribution of its stars, but by the principles which would operate however its stars were distributed.

From a purely logical point of view this device has certain obvious defects. In the first place it makes the pure assumption that the universe does possess immanent principles which express themselves in all phenomena. This might not be so. The "laws of nature" might be characteristics of our own place and time only. Again, it assumes that the region of space and length of time accessible to observation are sufficient to enable us to deduce these principles. This again might not be so. Not only might we find ourselves led to alternative sets of principles differing in their observational consequences by amounts too small to be detected in our limited sphere, but yet diverging widely when applied to a much larger range (a situation which nearly arises in the task of choosing between Newtonian and relativity mechanics), but also laws which are most prominent in a small region might fade into insignificance in a large region, as the quantum laws of atoms give place to a totally different set of "statistical" laws in bodies of observable size. These considerations should remind us of the essential uncertainty enveloping our statements about the universe.

An Analogy.

At the same time, there is a criticism frequently heard concerning such statements which is certainly not justified. The delusion that the complexity of an object increases in proportion to its size leads many writers to conclude that if we do not comprehend the part thoroughly we cannot comprehend the whole. It does not seem likely, as one writer has put it, that we can understand the universe when we do not understand Clapham Junction. Now this by no means follows because, as we have seen, we do not mean by the universe the mere aggregation of all existing physical objects, but the unity represented by that aggregation. We may know all about the properties of a billiards ball without knowing anything about its constituent atoms, because the term "billiards ball" denotes a unity whose properties are not at all the sum of the properties of the atoms. The real limitation to our knowledge of the universe, we repeat, does not arise directly from its vastness but from the fact that we have to make assumptions before we can talk about it at all.

Let us return to Newton's achievement. The characteristics of the universe having been located in principles, or laws, and not in specific facts, it did not seem likely that we should ever be able to know anything about the distribution of matter outside the actual region of observation. The laws of nature were supposed to operate whatever the physical structure of the universe; they could therefore hardly distinguish between one assumed structure and any other. Strangely enough, however, it was found that they could tell us something about the distribution of matter—always assuming that they were of universal validity. This possibility arises in the following way.

The Reverse Problem.

Although we cannot, from the observed behaviour of matter in an isolated region, deduce how matter is distributed beyond that region, we can solve the reverse problem, namely, determine the behaviour of matter in an isolated region when the distribution outside it is given. If, therefore, from reason or intuition we are led to think that the universe might be built up in any particular way, we can assume that it is so built up and then see if the behaviour of bodies in our own neighbourhood agrees with that which would result from our assumption. If so, the assumed distribution is possibly (though not necessarily) the actual one, but if not, it is certainly not actual.

Now such an investigation, assuming Newton's law of gravitation, was made towards the end of last century. If, as everyone then assumed, space was infinite, we should expect to find stars everywhere, and since there would be no reason to suppose one place to be more highly favoured than another, we should naturally assume that, on the coarsest scale at least, the density of distribution would be everywhere the same. What that density might be we could hardly anticipate, because the volume of space surveyed might be too small to be typical. The universe might, for instance, be like a sponge, which is of uniform density in the coarse sense that one cubic inch contains as much matter as any other cubic inch, but is far from uniform when two separate billionths of a cubic inch are compared, since one of them might be in a cavity and the other in the actual material of the sponge. Without attempting to assign a density, therefore, it was thought worth while to see whether a uniform distribution was consistent with the movements of bodies observed, and it was hoped that the comparison might set some limit to the possible large scale density.

The result was surprising. It turned out that no uniform distribution of matter was possible if Newton's law of gravitation was universally true: the fact that matter filled infinity would necessarily cause an infinite gravitational force everywhere, and no such force exists. Two explanations suggested themselves. The universe might not, of course, be filled with matter.

The stars might extend only to a finite distance from the Earth and then fade out into an infinite void of space. Such a distribution would be philosophically unsatisfying, but the possibility had to be admitted. On the other hand, the assumed law of gravitation might be very slightly inaccurate. In that case an infinite extension of uniformly distributed stars might co-exist with a finite gravitational force in our own neighbourhood. There was no means of deciding between these possibilities, however, and the matter remained in abeyance.

A Fundamental Change.

In 1915 a new law of gravitation actually was proposed—the general relativity theory of Einstein—which could be regarded as a very slight modification of Newton's law, and immediately the problem of the universe came up for reconsideration. The essential feature in the new situation, however, was not, as might have been expected, the small correction to Newton's law, but the much more fundamental change of attitude towards the whole problem of universal mechanics. Space, as an entity independent of matter, was abolished, and it became illegitimate to say anything about space which could not be expressed in terms of matter. The doctrine that space was infinite, for example, had to be re-expressed as the doctrine that there was no upper limit to the possible distance between two bodies. Expressed in this form it was seen to have an alternative, namely, that there was a maximum distance between any two bodies, just as an object at the north pole, if confined to the Earth's surface, is at a maximum distance from an object at the south pole. The decision between these alternatives, since it was essentially concerned with the behaviour of matter, was a problem of mechanics, not of pure geometry, and relativity mechanics indicated that the latter was probably correct.

There was nothing esoteric about this. It simply meant (in Newtonian language) that the forces between material bodies were such that however a body was set moving it would ultimately be drawn back again to the neighbourhood of its starting point. If it pleased anyone to think that, nevertheless, there must be infinite space outside the scope of its motion, he was at liberty to do so, but he would be needlessly encumbering his thoughts with ideas which were beyond the possibility of examination. It was much better to confine attention to what could be investigated and restrict the term " space " to the region accessible to exploration. On such grounds Einstein put forward his idea of finite but unbounded space filled with matter of uniform density.

It must be understood that here, as in pre-relativity thought, uniform density was an assumption. It now became possible, however, to make it without violating laws deduced from our own neighbourhood. Since the days when Copernicus destroyed the notion that the Earth was the centre of the universe, the idea of specially favoured regions (particularly when they are our own) has been unpopular. Hence there was philosophical satisfaction in reconciling the idea of a homogeneous universe with the characteristics of our own immediate surroundings.

This satisfaction, however, was short-lived. Extended observation of our immediate surroundings showed that its characteristics included a phenomenon which had not been taken into account. The extra-galactic nebulæ were found to be everywhere receding at speeds proportional to their distances. If the universe is homogeneous, then, nebulæ everywhere must be retreating from one another, but since our idea of a finite universe implies that their separation can never exceed a certain amount, they must eventually come together again. We are led, therefore, to think of a universe undergoing alternate periods of expansion and contraction. There are, however, two other possibilities. It appears that the new law of gravitation which the discovery of these motions requires is not inconsistent with an infinite universe uniformly peopled with nebulæ, so that after all we may have our infinite space. Or, alternatively, space may be finite, as before, but ever increasing in size, so that a body can never get further than a certain distance from us, but this distance steadily increases as time goes on. Which of these three possibilities is the true one we have no means yet of knowing.

Extreme Uncertainty.

The present position, then, is one of extreme uncertainty. The universe may be homogeneous and of any of the three types just mentioned. On the other hand, it may be inhomogeneous (*i.e.*, the density may be different in different places) in a variety of possible ways, and again of any of the same three types. This idea is philosophically less attractive, but it would remove certain difficulties connected with the age of the universe. Or again, our observations may afford too slender a basis for generalization, and the universe may be of a character at present unconceived. The fact that our expectation, from Newtonian mechanics, that distant nebulæ would be attracted is not fulfilled must warn us against neglecting this possibility. We leave off where we began: the universe eludes our apprehension. But we shall continue to pursue it.

The Truth About Snakebite.

By W. S. Barclay, F.R.G.S.

The universal dislike of snakes no doubt accounts for the widespread ignorance concerning their habits and the proper treatment of snakebite. The author has had much experience of snakes in many countries and discloses some interesting facts in the following article. He also corrects some popular superstitions for which there is no foundation.

THERE is still unusual ignorance concerning snakes both among educated and native populations. In India 20,000 people die yearly from snakebite. In Brazil the figure is given at 5,000, with "non-fatal accidents" many times as numerous. In Africa the number can only be conjectural but it must be large. Thus it is important that more should be known about snakes and that many widespread misconceptions about the treatment of snakebite should be removed.

Snakes rarely assume the offensive. They strike when disturbed or attacked, but their chief use of the offensive, as with all wild things, is to obtain food. All snakes are carnivorous, but having no external members it is impossible for them to hold and rend their prey. They are thus obliged to swallow it whole —another reason why they avoid the larger mammals, including man. The swallowing is made possible by an elastic attachment which permits the jaw to "dislocate" almost to the extent of the body opening. The teeth act as prongs to hold the prey and to keep the food moving inwards as the jaw moves. In order that a whole body may be swallowed in such a fashion, it is obviously necessary for it to be dead or passive.

Harmless snakes are quick and active movers. They pursue their prey, and having struck, immobilize the victim by strangling and crushing. The bite of a non-poisonous snake will show four rows of small, sharp, even teeth and a series of shallow and bleeding marks over the entire wound. These can be treated like the bite of any other small animal, that is, by being cleaned, disinfected and kept lightly bandaged till healed. The knowledge that the wound is non-poisonous will greatly assist recovery from shock.

Venomous Snakes.

Venomous snakes are sluggish and usually hunt prey at night, remaining inert and concealed in the daytime. Like many night-hunters, they are often nearly blind. Their bite will show two deep punctures, a short distance apart, looking like two red pin-heads, from which a drop or two of blood may ooze. These marks are left by the poison fangs, normally laid flat along the upper palate, but in an upright position when the jaw opens; these press on the poison-glands to which they are affixed and so allow the venom to drain into the wound. Once in contact with the blood-stream the usual symptoms are local swelling, blood coagulation and finally paralysis. After striking, the poison gland becomes depleted and may not accumulate its full quota of venom for a fortnight, or a very much longer period, depending on the size and habit of the snake. Bites from "deadly" snakes are thus not necessarily fatal, the issue depending on the amount of venom which has reached the blood, as well as the natural resistance of the victim. This resistance is strengthened to the point of immunity by the injection, as soon as possible after the accident, of serum, preferably prepared from the same species as has caused the wound. In the case of deadly bites, anti-poison serum is the only sure remedy unless the interval before administering the antidote has been prolonged unduly—say for more than half the period in which death normally ensues.

The Real Difficulty.

If no serum is immediately available, then the treatment for a venomous bite is as for high fever. Let the patient repose, with loosened clothing, and be kept as quiet as possible while the strength is kept up with sips of hot milk, beef tea, etc. Attempt no other remedy beyond keeping the wound clean and cool and turn a deaf ear to all, whatever authority or personal experience they cite, who give other counsel. Herein lies the real difficulty. The patient must be defended from those who, with the best intentions, wish to administer large doses of whisky and walk him about "to prevent drowsiness"; or irritate the wound by sucking or cutting, or even attempt amputation; who would rub in or inject permanganate of potash, chromic acid, gold chloride, hyperchlorite of calcium, or plain tobacco juice (nicotine); who would apply ligatures, to stop the circulation of a poison which has already circulated through the body at the very instant of striking, and who thereby hasten possible gangrene; and especially be depended from all local or native "cures," internal or external, compounded of animal, vegetable, or mineral mixtures whatsoever.

As the campaigns against other tropical scourges, such as malaria and plague, have so clearly shown, an alternative even better than the remedy which

science has placed in our hands is to take proper precautions against being bitten. Records show that seventy-five per cent of snakebites occur on the lower part of the leg or on the foot; indeed, the foot and ankle account for sixty per cent of the total. To go about plantation fields or forest paths booted and gaitered is, therefore, to acquire three-quarters of immunity from danger. Needless to say, the great bulk of cases occur among bare-footed labourers and natives, with whom the comfort and economy of bare extremities outweighs possible disability from snakebite—and, incidentally, the practical certainty of infection from tropical anaemia, or " hookworm." Europeans are seldom bitten and then chiefly in the hand. It is well for them to guard against sitting down, as the writer once did, on a comfortable tuft of grass without verifying the presence of its dangerous inhabitant; or sleeping in a rat and snake-infested verandah without the protection of a mosquito-net.

The habitual food of poisonous snakes is rats, mice and other small night rodents, in the order of importance given. The removal of food debris from all living quarters, by burial or burning, should therefore be insisted upon. To make war on rats is to do so equally upon snakes, dangerous or otherwise.

Sluggish Movements.

The statistics for place-wounds given above are again determined by the physiology of the snake. The bulk of the poisonous varieties are a yard or under in length, while it must be remembered that all young snakes are fully venomous practically from the time they leave the egg. The venomous snake, whose movements are sluggish, will not expose to an enemy its outstretched body, whose long line of vertebrae, with the moving ribs attached, make it extremely vulnerable to attack. The usual fate of a helpless snake is to be eaten alive by ants. It is the non-poisonous variety which runs in to attack: the poisonous kind coils before striking. Its effective range is no more than one-half of its length, which in practice means from eighteen to twenty inches from the centre of the coil. No poisonous snake will strike without caudal support for fear of over-balancing. There are a few notable exceptions, such as the African mamba and the Indian Hymadryad, which are both large, poisonous and at certain seasons active in attack. Poisonous snakes may easily be captured or examined by lifting them from the ground by a sharp-angled crook made at the end of a stick or piece of stout wire. Deprived of its purchase the reptile wriggles helplessly and may thus be handled—at a safe distance—like so much rope. Among the natural enemies of the snake are certain birds of prey, mostly confined to Africa, as well as the mongoose, and the common pig, whose subcutaneous fat-layer places the blood-vessels out of reach of the poison fangs. The most effective of all, perhaps, is a cannibal snake, known in Brazil as the Massurana (*Oxyrhopus Cloelia*) which, though harmless to man and animals, lives entirely on other snakes to whose venom it is immune.

Snake Fables.

Snake fables and superstitions are so numerous that space only allows mention of the more notorious. First place may be given to the alleged " fascination " of the snake's eye. This probably has its origin in the gradual paralysis that affects the victim, while the snake watches for an opportune moment to strike again or to close in for final deglutination. Tree-snakes have been observed to strangle small birds with their tails, an operation difficult to identify exactly amidst dense foliage. Again, birds whose nests are approached by robber snakes will try to lure them to a distance as they do other enemies. But so far from being in any way " fascinated," none of these small fry, even when in captivity and close to their dangerous hosts, show any fear of snakes at all. A guinea-pig will play over the coils where-in it may shortly be entombed; hungry rats have bitten at the coils of a torpid cobra, while a deer fed to a python was seen to butt the latter back to the temporary refuge of its blanket.

Europeans who keep a milk cow in the tropics are always liable to hear one morning that the supply has fallen short, because of a large snake which has been seen to creep near the animal for warmth, either in the open or in its stall, and sucked it without disturbance. The explanation of this familiar phenomenon is, of course, that the milk has been requisitioned for the use of the cow-herd, or of his numerous relatives!

Since the snake is not a mammal, it is as incapable of " sucking " as a bird or fish would be. Snake-charmers usually obtain contributions from spectators in proportion to the supposed deadliness of their pets. Part of the immunity claimed depends on constant watchfulness and an intimate knowledge of their habits. Usually the poison fangs have been removed. Without this elementary precaution most snake charmers die from snake-bite sooner or later, unless they have access to the serums that they profess to despise.

The Pasteur Institute in India, the Snake Institute at Port Elizabeth, South Africa, and the Butantan " snake-farm " near Saõ Paulo, Brazil, are the head-quarters of snake research and cure.

Book Reviews.

Adam's Ancestors. By L. S. B. LEAKEY. (Methuen. 7*s.* 6*d.*).

In "Adam's Ancestors" Dr. Leakey surveys present knowledge relating to pre-palaeolithic and palaeolithic man. His book is made to serve a double purpose. It is an up-to-date account written for the layman; at the same time it sets out for the consideration of the specialist the author's interpretation of the facts in matters which are obscure or the subject of controversy. Surprisingly enough he has not fallen between two stools. He has successfully avoided over-simplification, and has given a sufficiently detailed account of the characteristics and relations of the variety of cultures and industries into which archaeologists now classify the material of the Old Stone Age. For an example of his skilful handling of a question of which the technicalities might well dull the inherent interest for the layman, the reader may turn to the discussion of Mr. Reid Moir's pre-palaeolithic discoveries in the Early Pleistocene (or late Pliocene) of East Anglia and of his view of their interpretation. His account of early types of man carries special weight as the work of one who discovered in East Africa the earliest known ancestral type in the direct line of *Homo sapiens.*

With the discovery of new cultures and industries of the early Stone Age in various parts of the world, and the refinement in classification by intensive study of those which were already known, prehistory is rapidly assuming a complexity of which the difficulties are underlined rather than lightened by its nomenclature. It also exacts some, if not necessarily a very extended, knowledge of a number of ancillary sciences. Hence if capable guidance is lacking much of the student's time may be wasted. It is pardonable to emphasize these difficulties, if only to have the pleasure of pointing out how admirably they are smoothed away by Dr. Leakey.

The Atom. By DR. JOHN TUTIN. (Longmans, Green and Co. 6*s.*).

Dr. Tutin is a young and successful engineer who has hitherto efrained from engaging himself in the fascinating but thorny field of atomic physics. Now comes from him a novel and interesting theory of the constitution of the atom which is intended to challenge the view that has gained universal acceptance from physicists since its promulgation in 1913—the theory of Lord Rutherford and Professor Niels Bohr. On the Continent alternative theories of the atom come out once every two or three months, only to die of scientific neglect, but in this country Dr. Tutin's has been the first to come prominently into notice. The novelty of the theory is extended to the manner of its presentation. Scientific discoveries are announced in the learned journals in highly technical language with wealth of recondite allusion; popularization may well be left to a later day when the world of science has become convinced. Dr. Tutin's theory of the atom, however, aiming though it does at overthrowing the highly technical atom-model of twenty years' standing, comes out in book form with an announcement on the wrapper that it is addressed not merely to the learned but to the general reader fond of science. It is not impossible that someone like Dr. Tutin might conceive of an atom which could give the *coup de grace* to the Rutherford-Bohr atom, but the suggestion that the supplanting theory could be made intelligible in the first instance to the general reader is simply ludicrous.

In the Rutherford-Bohr atom the whole mass is imagined to be concentrated at the centre, in the tiny nucleus which for each element bears a unique charge of positive electricity. Thus, in hydrogen the charge is 1, in oxygen 8, in tin 50, in gold 79, and in uranium, the heaviest of known elements, 92. Circulating round the heavy, positively-charged nucleus are electrons—single charges of negative electricity of negligible mass—equal in number to the charge on the nucleus, so that the atom as a whole is electrically neutral. Bohr showed in a satisfying manner how these electrons were disposed around the central nucleus, and his work and the quantum mechanics which has been developed since have extended the range of phenomena in both physics and chemistry which can be well explained without further hypothesis. The model explains, for example, the Periodic Classification of the chemical elements, the conductivity of metals, paramagnetism, ferromagnetism, atomic and molecular spectra, and the origin and nature of bonds in chemical compounds.

Dr. Tutin, however, does not think all of these explanations satisfactory. He is dissatisfied with the ability of the atom to explain the nature of chemical bonds. He thinks it fails to explain "why some atoms emit light and others do not, why some are electrical conductors and others insulators, why some are magnetic and others non-magnetic." And there are further objections. It should be said that these objections are not shared by those who have a much wider experience of the subjects into which the Rutherford-Bohr atom-model enters than has Dr. Tutin. Nothing really has yet arisen which is not at least qualitatively explained by this atom-model. It does appear that Dr. Tutin's objections arise not through any intrinsic demerit of the Rutherford-Bohr atom, but on the simple ground that Dr. Tutin does not understand perfectly what he has written about. He has neither done experimental work on the subject, nor haunted the laboratories where he might have acquired inside information. He has informed himself as accurately as one can at second hand, but in science, fortunately or unfortunately, second hand isn't good enough.

He does not merely criticize, however, he creates. He puts forward modestly and rather tentatively an alternative atom which overcomes, he argues, the objections felt to the accepted atom. Put shortly he inverts everything. With him the nucleus contains not the whole of the atom's mass, but none of it; not a fixed number of charges of positive electricity but a fixed number of charges of negative electricity; the outer space of the atom contains not electrons only but the massive positive electricity in ordered array, together with some negative electricity. He ingeniously postulates that these moving masses of positive electricity, rotating round the nucleus, are rigidly bound to it. By this *ad hoc* assumption he gains novelty without losing, he thinks, any of the merit which he admits belongs to the older atom-model. But this cannot be. The Rutherford atom was invented to explain the "scattering" of the swift alpha-particles (ejected by radioactive elements) by the atoms they encountered in their flight; it explains the experimental results on scattering excellently. But you cannot have the atom's mass on the circumference of the atom, as Dr. Tutin postulates, and have it concentrated at the centre, as Lord Rutherford postulates, and get the same scattering effects. Dr. Tutin's model demonstrably gives scattering results which cannot agree with experiment, so that at the first hurdle the model comes a cropper. It breaks down also on the subject of specific heats. On the Rutherford-

Bohr atom argon should have a value for the ratio of its specific heats of 1.67; on Dr. Tutin's atom the value should lie between this value and 1.4, say 1.5; the experimental value is 1.67. But it is on the subject of isotopes that the ordinary scientist will recognize the inadequacy of Dr. Tutin's atom. It is universally agreed that the electrical properties of isotopes are so exactly similar that it is not straining words to describe them as identical. Yet Dr. Tutin leads one to believe that in such elements as lithium and silicon one of the isotopes is a conductor and the other an insulator. If he could prove this he might one day be in the running for a Nobel Prize, but he will not prove it.

It would be unfair to criticize this atom-model further. A short, tentative, sketchy essay could not be expected to dislodge the solid belief in the Rutherford-Bohr atom with more than twenty years' theorizing and massive experimental work behind it. Dr. Tutin should either have said much more or left all unsaid. The best that can be said of his atom is that it is attractive from an engineer's point of view; it is static rather than dynamic; it seems solid rather than nebulous; it looks the kind of thing that could explain physical properties like cohesion fairly simply. But there are too many assertions at a venture and *ad hoc* assumptions about it. And in point of exact fact where it can be tested against the older view it must be accounted to have failed.

A. S. RUSSELL.

The A B C of Biology. By C. M. YONGE. (Kegan Paul. 4*s.* 6*d.*).

Probably no branch of science is more difficult than biology to summarize concisely; the manifestations of life are innumerable and infinitely varied, and with one outstanding exception—the concept of evolution—there are no "general principles." In less than 250 pages, Professor Yonge presents a lucid and accurate review of the present position in biology. In the first part of the book he emphasizes the distinction between living and inanimate matter, discusses the possible mode of origin of living matter, and outlines the broad distinctions between plants and animals. In the second part he considers the mechanisms of living matter.

Writing of modern views on the nature of life, the author emphasizes the fact of a common origin for all living matter in its infinitely diverse manifestations. Yet, despite all the triumphs of physiology and genetics, we are no nearer to the interpretation of living matter than we were in the days of the "war" between the mechanists and the vitalists fifty years ago. One by one the various mechanisms of nature are studied and explained, but the nature of life itself remains obscure. Will it ever be explained? It is possible, as the author suggests, that before the nature of life can be elucidated and living matter brought into line with inanimate matter, some entirely new concept will have to appear. One of the outstanding results of modern physical research has been the advent of the notion of "wholeness"—the collapse of the idea of particles—and many eminent physicists have stated their belief in the necessity of a new view of organism. The notion of "wholeness" also shows signs of arising in biology, and if, as the author suggests, it proves capable of experimental proof, it may supply the new concept for which we are seeking.

We regret that the price of Mr. E. N. Digweed's book, *Stress Diagrams and Drawing Office Practice*, advertised by Messrs. Williams & Norgate in the June issue of *Discovery*, was incorrectly given as 18s. 6d., whereas this figure should have been 8s. 6d.

A Bibliography of Sir James George Frazer, O.M. Compiled by THEODORE BESTERMAN. (Macmillan. 12*s.* 6*d.*).

Last January Sir James Frazer celebrated his eightieth birthday, and certain of his friends and admirers, through the good offices of the Folklore Society, have combined to do honour to the author of *The Golden Bough* by the publication of a bibliography of his work, a chronological catalogue of the many productions of his pen in fifty-five years of authorship in the service of science and letters. The volume is published by subscription. In addition to the bibliography proper, it contains a list of subscribers, an introductory note by Sir James himself, portraits and facsimiles of annotated pages of one of Sir James's books, showing his method of working—an illuminating comment, it may be added in parenthesis, on the growth of the various editions of *The Golden Bough*.

The list of subscribers is impressive, not merely for their number—that was to be expected—but for their variety in nationality and in calling. Politicians from Prime Ministers downward, men of law, men of letters and of art, as well as scientists, are represented. The reason for this widely rendered homage is not far to seek. Sir James, through his books, has touched many sides of life. Those who know him in *The Golden Bough* only may well feel surprise, on glancing through this bibliography, to see the variety of subjects upon which he has written with authority and distinction. It is something of a far cry from totemism and exogamy to the poet Cowper and the pieces of purely literary character in *The Gorgon's Head*, among which will be found the delightful recreations, rather than imitations, of Addison's *Sir Roger de Coverley*, written with a charm no less than that of their model.

Secrets of the Red Sea. By HENRY DE MONFRIED. Translated by HELEN BUCHANAN BELL. (Faber & Faber. 12*s.* 6*d.*)

M. de Monfried has spent twenty years in the Red Sea, on a sailing boat which he built himself and was manned by a native crew. He is described by the publishers as an "individualist at odds with civilization"; which puts the case mildly. In the course of his unconventional life afloat the author has engaged in pearl fishing, smuggling and gun-running, and it is no surprise that he found himself on many occasions in trouble with the authorities. The book is useful for the light which it throws on the lives and habits of the Arabs and Africans who inhabit the shores of the Red Sea. Of these the author writes with unusual intimacy. As a story of adventure the book would be hard to beat.

The Dinosaur. By W. E. SWINTON. (Murby. 15s.).

The dinosaurs started upon their great career at a period of general aridity, during the Trias—conditions which encouraged activity and evolution. Dr. Swinton derives them from the *Pseudosuchia*, a widely ranging group of small, slender reptiles in the Permian. They had a great reign, about a hundred times as long as man has so far enjoyed. Gradually developing in power and variety, they reached their climax at the end of the Cretaceous, a period we may estimate in the neighbourhood of 100,000,000 years, nearly twice as long as the whole of the Tertiary Epoch.

They became enormous. *Triceratops* is suggestive of a ten ton rhinoceros; *Diplodocus* was eighty-five feet in length, the *Brachiosaurus* of Tanganyika as much, while *Brontosaurus* must have weighed a good thirty-eight tons. These ponderous

brutes seem mostly to have wallowed in marshes and browsed upon the vegetation. They were the prey of the carnivorous dinosaurs, which must have been the most fearful creatures that have existed upon the earth. In Wyoming Dr. Wortman found portions of a *Brontosaurus* with the tail bones scored and chewed by *Antrodemus*. But, as Dr. Swinton suggests, the battles in which these animals engaged must have had the stiffness of the amateur and none of the smooth professional skill that we see to-day in the cats. With the growth of attack came defence, as always, and the tank-like *Ankylosaurus*, " the most ponderous animated citadel the world has ever seen," had only to squat tight to defy even *Tyrannosaurus*. Yet even these massive, armour-plated *Orthopoda* are not more fantastic in detail, but only in size, than many modern lizards, such as *Phrynosoma* or *Zonurus*.

Discussing the problem of their extinction, Dr. Swinton shows that it cannot have been due to any competition from the puny mammals, then in their infancy. He points out that favourable conditions on land had led to a high degree of specialization, of development of the body at the expense of the brain, which led to sluggish reactions, loss of adaptibility, greater demand for food, reduced fertility and slower rate of breeding with longer adolescence. When they were at their *apogee* came the Laramide revolution, leading to a general uplift which drained the vast marshy areas haunted by these brutes. Too fixed, their racial vitality lowered, they were unable to meet new conditions, and disappeared, to leave the world clear for the consequent development of mammals.

The discovery of their eggs in Mongolia led to the suggestion that Central Asia was the centre of dispersal of the vertebrates, but Dr. Swinton cannot accept this view. Incidentally, there were dinosaurs' eggs from East Kent in the British Museum long before the American expedition to Mongolia, and there are no less than 132 species described from Britain, including the first known one, discovered in the Stonefield quarries exactly a hundred years ago by Dean Buckland, and the romantic Iguanodon of the Weald.

Correspondence.

IS ALUMINIUM DANGEROUS FOR COOKING ?

To the Editor of DISCOVERY

SIR,

Having experimented with aluminium on rabbits for some years and having had practical experience of the role it plays in disease in man, I trust you will find space in your columns for this letter. The combatants in the battle of aluminium are sharply divided—one camp holds the theorists and experimenters who are more greatly interested in the industry than in practical medicine, whereas in the other are the physicians who are concerned only with their patients. The former assume that not sufficient aluminium can get into the system from cooking utensils to cause disease, and support their assumption with the failure to find either the metal or organic changes in the body following the administration of comparatively large quantities. The latter have noticed certain signs and symptoms of disease vanish after discarding aluminium utensils to return on their renewal.

There is no relationship between dose and toxic effects as a drug may be a potent factor in causing and aggravating disease when it cannot be detected in the body. A drug in even undetectable form out of the body may produce manifestations of disease in the body which would fail to appear after the administration of large quantities. In the body the action of all chemical compounds is more physical than chemical. As a matter of fact there is no metal better able to produce mesenchymatous changes or arterio-sclerosis in rabbits than aluminium and the organs selected for attack are the lungs. One cc of a saturated aqueous solution of aluminium acetyl acetonate injected intramuscularly produces pneumonia a few days later almost without fail. In man aluminium tends to advance arterio-sclerotic changes which may aggravate vascular degeneration, rheumatism, eczema, etc. It is a potent cause of flatulence as well as of Herpes buccalis. The signs and symptoms of disease it causes and aggravates are more readily occasioned by small quantities of the metal such as may enter the food from cooking utensils than by large quantities such as may be taken in the form of alcohol. I have known cases of Herpes buccalis relapse after merely eating an egg boiled in an aluminium saucepan.

Finally, it should be noted that the homoeopath prescribes aluminium in cases of arterio-sclerosis. The subject is more fully discussed in " The Nature of Disease " Journal, Vol. III.

Faithfully yours,

J. E. R. McDONAGH.

42, Wimpole Street, London, W.
6th June, 1934.

The author of the article on this subject in our June issue (Mr. J. H. Coste, Medical Department, London County Council), replies to our correspondent as follows :—

" Dr. McDonagh belongs to the camp of practising physicians who are concerned only with their patients. He is, I think, morally bound to give them such advice as his experience may suggest as proper. On this aluminium question I do not belong to any camp at all but, from my own long experience at home, and from repeated investigation of the literature of the subject, I have formed the opinion that aluminium is as suitable as any other material for cooking vessels. My grown up, healthy offspring, use it in their own homes. It may be that exceptional people are affected adversely by its use, or even that they think they are ; such people are well advised to use vessels of other materials, so long as they do not use enamelled ware lined with antimonial glaze.

" Whatever the relationship between dose and toxic effects, and there must be some, I am ready to agree that it is unlikely in all cases to be one of simple proportion. I cannot see what bearing the intramuscular injection of a rather unusual aluminium compound has on the use of aluminium vessels for cooking, since any of the metal or its compounds reaching the body from cooking vessels or containers must do so through the mouth, and also it is not usually suggested that pneumonia results from using such vessels. As to the egg cooked in an aluminium saucepan, it seems incredible, having regard to the small amount of aluminium that could go into solution under such conditions, and the double protection of shell and membrane, that appreciable amounts of aluminium could penetrate into the albumen, but, as Dr. McDonagh's patients, no doubt, had a choice of other vessels, I think that as a physician rather than as an experimenter, he was wise to issue a prohibition which was psychologically satisfying to the patient. I think that only carefully conducted experiments with controls would solve the point whether the aluminium caused the relapse, and I know that hundreds of thousands of people use aluminium vessels for many purposes in connection with food without being aware that their health is suffering thereby."

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